Pediatric Concussions/Pediatric Sudden Cardiac Arrest

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Conflict of Interest Disclosure
Dr. Bomze certifies that, to the best of his knowledge, no affiliation or relationship of a financial nature with a commercial interest organization has significantly affected the views on the subject that will be presented.

Objectives
- Explore the scope of concussions and sudden cardiac death in children.
- Evaluate the diagnosis of concussions and disorders causing sudden cardiac death.
- Outline treatment and prevention strategies for concussions and disorders causing sudden cardiac arrest.
- Discuss various state laws pertaining to concussions and sudden cardiac death risk.
- Apply selected strategies for effective medical records review in cases involving concussions and sudden cardiac events.
CONCUSSION CASE STUDY

16yo male soccer player collides head to head with the opposing player while trying to head the ball. He is a little dazed, no LOC, answers questions appropriately, and is alert and oriented.

His coach is aware, but he continues to play. He has another head to head collision later in the game and falls to the ground. He was unconscious and could not be resuscitated—there was no EMS on site and no physician or trainer on site.
His autopsy revealed an acute cerebral bleed. He had no history of prior head injuries and no significant medical history, no relevant family history, no medications, and no prior injuries.

He was cleared on his pre-participation exam by his pediatrician 2 weeks before this game.

What key facts and information would you need in order to decide if there is a possible deviation in standard of care by the pediatrician? Are the coach and school potentially liable?
Concussions in Pediatrics

- Hot topic—medicine and the media
- Recent changes in evaluation and management
- Sports-related concussions common (300,000/yr. reported)

Concussions in Pediatrics

- Total sports-related and recreational concussions—3.8 million
- 8.9% of all high school injuries

- Demographics—girls higher rate than boys overall—? weaker neck muscles/smaller head mass
- Football—highest risk male sport—soccer and basketball for females
Ice hockey, rugby, and lacrosse also with high risk

Many unreported cases

Risks for cognitive as well as physical complications

Can affect school, sports, social/family relationships

Recognition and education very important

**Concussion**

Complex pathophysiological process affecting brain

Induced by traumatic biomechanical forces

Can be direct blow to head, face, neck or elsewhere on body with force transmitted to the head
Evaluation

- Many grading systems in past no longer used
- Evaluation measures used for individual return to play decisions

Symptom-based approach now used
- Individualized assessments needed

Signs and Symptoms

- 4 categories: physical, cognitive, emotional, sleep
- Headache most common symptom
**Signs and Symptoms**

- Loss of consciousness - less than 10% of concussions -> 30 sec is risk for more significant injury
- Amnesia - retrograde and anterograde (may be more serious)

**Physical Signs and Symptoms**

- Headache, nausea, vomiting, balance problems
- Visual problems, fatigue, sensitivity to light and noise
- Dazed, stunned - “bell rung”

**Cognitive Signs and Symptoms**

- Similar to ADHD
- Mentally “foggy”, slowed down, difficulty with concentration and memory
Cognitive Signs and Symptoms

- Forgetful of recent information, confusion about recent events
- Slow response to questions-repeats questions

Emotional Signs and Symptoms

- Depression, anxiety
- Irritability, more emotional
- Sadness
- Nervousness

Emotional Signs and Symptoms

- Sleep
  - Drowsiness
  - Sleeping less than or more than usual
  - Difficulty falling asleep
Recognition
- may be difficult
- athletes may not recognize symptoms
- athletes may not understand symptoms

Recognition
- cognitive impairment from injury may delay recognition
- fear of disclosing and not playing

Concerning Signs and Symptoms
- LOC > 30 sec
- retrograde amnesia
Concerning Signs and Symptoms

- seizure
- neck/cervical spine pain or weakness or numbness of extremities

Assessments-on the Field

- assess for neck injury/pain and immobilize cervical spine as needed
- EMR to hospital if LOC or suspected neck injury
- neurological exam

Assessments-on the Field

- sideline assessments for concussions - SCAT 2 or SAC – cognitive and balance testing, symptom scales-wait to perform
Immediate Management After Assessments

- remove athlete from play-no return that day
- monitor for several hours

Immediate Management After Assessments

- ER referral-repeated vomiting, severe or worsening headache, seizures, unsteady gait, altered mental status

Office/ER Medical Evaluations

- head and neck exam
- neurological exam
Office/ER Medical Evaluations

- cognitive assessment-standardized tools (SCAT-SAC)
- neuroimaging (CT/MRI) only needed if suspect structural brain injury

Follow-up

- clear and specific discharge instructions for return to office/ER
- no return to play on day of injury

Neuroimaging-CT/MRI

- little or no contribution if only concussion
- used if suspicious of intracranial structural injury, --neck injury (cervical spine), or skull fracture
Neuroimaging-CT/MRI

- Intracranial hemorrhage- (subdural, epidural, intracerebral, subarachnoid)

Indications for Neuroimaging

- Changing or worsening signs and symptoms-severe headache, seizures, focal neurological signs (one side, face)

- Repeated vomiting, significant drowsiness, slurred speech, loss of orientation, neck pain, significant irritability-LOC > 30 sec
Neuroimaging

- CT first choice in first 24-48 hours
- Better for skull fractures, cheaper, easier, faster—radiation is concern

MRI good for cerebral contusions, white matter injury
- Newer MRI technologies may be better—not tested yet

Neuropsychological Testing

- Objective measurement of brain function
- More common recently
Neuropsychological Testing

- does not diagnose concussion or indicate when athlete can safely return to play
- computerized programs available (Impact form used in schools)

- athletes with concussions show deficits compared to baseline—should be high school age or older
- do pre-season for baseline and then after concussion—caution for athletes who intentionally fail pre-season test

- neuropsychologists not necessary to perform/interpret computerized tests
- no established protocols after a concussion
Management After Acute Phase

- large majority patients recover completely within days to 1 week
- goal is to allow recovery as soon as possible

Management After Acute Phase

- need adequate time for complete physical and cognitive recovery
- extra caution because young brains still developing

Cognitive Rest

- common-decreased concentration, memory, attention taking tests
- reading can worsen symptoms—even pleasure reading
Cognitive Rest

- may need temporary leave of absence from school, shortened school days, extra time for tests - need good communication between all school personnel and families
- will need to make up work and tests

Cognitive Rest

- students appear well - needs understanding of school
- includes avoidance of computers, video games, TV - also possibly loud music - avoid driving

Physical Rest

- no physical exertion until asymptomatic at rest
- ? subthreshold training - light aerobic workouts if post-concussion symptoms resolved
Physical Rest
- broad restrictions of activity - aerobics, weight training, PE classes, sexual activity
- leisure activities (bike-riding, skateboarding, etc.) should be restricted

Recent Legislation
- based on Washington state law - enacted in PA.
- requires school boards and PIAA to develop educational materials for students, parents, coaches, and trainers

Recent Legislation
- parents and athletes sign informed consent form acknowledging dangers of concussion (pre-season)
- immediate removal from activity if concussion signs and symptoms - must be cleared by health care professional
Return to Play

- Individualized athletes vary in recovery
- No return if symptoms at rest or with exertion
- Longer recovery if younger in age - more conservative

Concussion Rehabilitation

- Minimum of 5 days for full recovery to participate
- Must be asymptomatic with each progression

Concussion Rehabilitation

- If continued symptoms, need reevaluation by health care provider
- More time if prolonged symptoms or recurrent concussion
Prevention

- protective equipment

- mouth guards-no conclusive evidence of concussion prevention-reduce dental trauma

Prevention

- helmets-skiing and snowboarding efficacy for prevention-? newer football helmets may protect

- soccer headgear-mild concussion protection from head collisions-better for soft tissue injuries

Complications

Long-term effects
- not known for young athletes
- possible chronic traumatic encephalopathy
- persistent cognitive, visual processing problems
Complications

Long-term effects
- lower grade point averages if 2 or more concussions
- second-impact syndrome-more common if younger

Complications

Long-term effects
- return to play before symptoms clear
- second head injury-cerebral vascular congestion-cerebral edema-death

Post-concussion Syndrome

• greater than 3 months of symptoms-3 or more symptoms
• fatigue, disordered sleep, irritability, aggressiveness
Post-concussion Syndrome

- dizziness, vertigo, anxiety, depression
- personality changes, apathy, decreased school performance, decreased attention, decreased memory

Retirement from Sports

- no evidence-based guidelines
- ? 3 concussions in 1 season or post-concussion symptoms more than 3 months
- referral to specialist in sports-related concussion

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HOT TOPICS IN PEDIATRICS:
CONCUSSIONS & SUDDEN CARDIAC ARREST

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SCA CASE STUDY

8yo female complains of fatigue, chest pain, palpitations, headache, muscle aches, and low-grade fever for 2 days. She has mild cold symptoms as well. Her mother takes her to the pediatrician. She relays these complaints and the nurse/MA and pediatrician ask more questions. Temperature and blood pressure are recorded in the chart. The pediatrician examines the child and concludes that she has a flu-like viral illness. She has a normal cardiac and pulmonary exam. She goes home and later that night she passes out and the local EMS is called. They arrive in 5 minutes to find the patient collapsed and without a heart rate. They attempt resuscitation and she could not be revived.
One month later you receive the lawsuit complaint and you are asked to defend the pediatrician. What are the issues here? Is this case defensible? What do you want and need to know? Could this have been prevented? What do you do next?

**Background/Epidemiology**

- No central registry
- CDC estimates 2000 patients/year <25 years old will die of SCA
- < 100 cases/year of SCA in young competitive US athletes—underlying cardiac disorders pose higher risk
- Italian study—baseline incidence of SCA in young athletes of 1/25,000
- 2.5 times risk of SCA for young athletes compared to age-matched non-athletes

**Predisposing Cardiac Disorders for SCA**

**Structural**

- Hypertrophic cardiomyopathy
- Anomalous coronary arteries—Pete Maravich
- Ruptured aorta—Marfan syndrome—Flo Hyman
- Myocarditis, mitral valve prolapse, left ventricular outflow obstruction (aortic stenosis, coarctation of aorta)
Electrical
- long QT syndrome
- Wolff-Parkinson-White syndrome
- catecholaminergic ventricular tachycardia (CVT)
- complete heart block

Other
- drugs, stimulants - cocaine, amphetamines, ephedrine
- pulmonary hypertension
- commotio cordis

Genetics of SCA
- rapidly progressing area - genetic mutations
- specific genetic markers alone don’t allow risk stratification for outcome
- Marfan syndrome, long QT syndrome, hypertrophic cardiomyopathy among those with genetic markers - several more
- goal is to identify prospectively high risk individuals and family members

Family History
- very important to obtain thorough and extended family history
- key risk factors
- sudden death from any cause < 50 years old
- death from heart problems < 50 years old
- unexplained fainting or seizures, congenital deafness (long QT)
- history of any family members with the high risk cardiac conditions
- any family members with pacemakers/implanted defibrillators
**Warning Signs and Symptoms**

- may be relatively common in patients with structural and electrical cardiac disorders
- syncope (fainting), near fainting, chest pain/pressure, palpitations during or after exercise
- fainting after emotion or startle

**Clinical Challenges**

- most deaths from fatal ventricular fibrillation (VF)
- brief VF episodes can result in syncope/near syncope, and seizure-like activity
- confusion with neurological problems-delayed diagnosis
- sudden unexpected death in epilepsy-seizures leading to cardiac death-SIDS (long QT, CVT)
- chest pain non-specific with unlikely cardiac cause
Most common causes of chest pain in children and adolescents—musculoskeletal, pulmonary, GI, psychological.

Chest pain not seen in electrical disorders of the heart.

Chest pain more common in cardiomyopathies, coronary artery anomalies, aortic rupture in Marfan syndrome.

Can get wheezing with exercise in cardiomyopathies, mitral insufficiency (mitral valve prolapse), pulmonary hypertension.

Normal pulmonary function tests and lack of response to bronchodilators are key for cardiac concerns.

Near drowning and drowning can result from long QT, CVT.

Febrile seizures may be presentation for one of the electrical anomalies.

Screening

- Identifies higher risk children—restrict activities.
- Can’t identify all patients at risk.
- No screening protocol validated as highly effective.
- Time, resources, expense and reimbursement issues.
Sports pre-participation evaluations (PPE)-CV risk assessment

- nearly half of SCA patients have warning signs/symptoms or family risk
- can identify many at risk-EKG and Echocardiograms
- possible, yet unsubstantiated role of PPE
- more effective to perform thorough CV risk assessments throughout childhood and adolescence

Sports PPE

- need to update history and PE over time-new information
- need complete family history data
- Formal PPEs exclusively omit >25 million children not participating in sports
- May not get formal PPE until high school-PIAA—not all schools
- need qualified professionals and complete history and PE
- AHA and AAP recommendations for PPE for competitive sports
- no validation of any of the screening risk assessments

Key Warning Signs/Symptoms

- fainting, near-fainting, seizure without warning and during exercise or auditory triggers
- history of exercise-induced chest pain or shortness of breath
- family history of sudden, unexpected, unexplained death < age 50
- family history of disease predisposing to SCA(HCM, Long QT, etc.)
EKG Screening
- not used in US as mass screening tool—may not be cost effective
- Italy and Japan data: greater sensitivity than PPEs for SCA risk
- Most recent AHA guidelines do not recommend EKG mass screenings
- False positives and negatives: costs, time, feasibility, medico-legal issues
- Wide-scale screening needs updated normal values
- Recognition of athletic hearts: low heart rates, large left ventricle
- Need more data: CHOP studies in progress

Molecular Autopsy
- New genetic data evolving
- Autopsies now with genetic studies: not routine
- Genetic testing of family members after sudden cardiac death
- More research needed

Primary Prevention
- Depends on diagnosis and specialist treatments and restrictions
- May include medications, avoidance of certain classes of medications
- Activity restriction guidelines: counseling
- Family emergency preparedness
Secondary Prevention
- resuscitation protocols
- EMS and 911 protocols
- bystander CPR—compression only may be effective
- automatic external defibrillators for older than 1 year-ventricular fibrillation

Act 59 in PA-SCA Prevention
- recently passed and just enacted for Fall sports season now-developed by the PA Departments of Health and Education
- similar to concussion prevention— all student athletes—middle and high schools
- not for elementary students or for all doing PE classes
- ongoing development of program

Key Elements of Act 59
- educational information for student athletes and parents—sign form pre-season
- educational training program for coaches and trainers before year starts-certified training program
- informational meetings may be held to educate all school personnel, parents, and students
- does apply to practices, games, and before games—also cheerleading included
Act 59

- warning sign/symptom list – very inclusive
- removal from play if any sign/symptom present before, during, or after practices and games
- many different school and professional staff can remove student
- must be cleared in writing by physician, nurse practitioner, cardiologist before returning to play

Act 59-Implications/Concerns

- no formal educational materials available now nor formal training program for coaches
- training program for coaches must be provided by a state-certified trainer
- penalties for coaches who don’t follow guidelines - not established
- need updated PIAA forms - recently added forms made available was not available to all schools by pre-season in August

- vagueness and non-specific warning signs in PIAA form includes some not in AAP and AHA guidelines how to implement
- current PIAA form states SCA, if underlying condition is diagnosed, can be prevented - not true
- PIAA form also includes symptoms before exercise - guidelines emphasize during or after exercise - not specific
• PIAA form for health history does not include many of the high risk cardiac diseases

• difficulty of obtaining complete history and family history-family may not know

• logistics of family/health history being completed on forms prior to PPE and ability of coaches and athletic trainers to review all information

• logistics of communication between students, parents, coaches, trainers, school personnel

• logistics and practicality of enforcing strict warning sign/symptom list-very non-specific

• logistics of clearance and return to play-time needed

• logistics, availability, costs, time involved if cardiologists need to evaluate students

• students, parents, coaches not adhering to guidelines-pressure to play

• overall time, expense, and effectiveness of program and resulting tests

• logistics of practices and games after school hours-no nurses available

• trainer/coach communication and availability

• EMS, 911, CPR, ER, and defibrillator availability-many sports at same time
Summary

- recognition of warning signs and symptoms
- family history and pedigree
- standardized PPE forms (PIAA needs some updates)
- appropriate referrals and testing/evaluations when needed
- educational programs for Act 59 and CPR and automatic defibrillator use
- Act 59 enactment and implementation—school emergency response
- continued studies and use of evidence-based studies

Chest Pain

- no positive predictive value for cardiac or other pathology
- typical (non-cardiac)
  - pain at rest, sudden, sharp
  - prevents deep breathing
  - arrhythmias don’t cause chest pain
  - often get pain followed by palpitations—normal
- red flags—dull pain, associated with exercise, relieved by rest
- reproducible pain
- rare cardiac pain in children
- numbness or radiation down extremities not predictive of cardiac pain
Chest pain

- large ER study < 2% ER/clinic visits with chief complaint of chest pain (69 of 3700 visits)
- only 9 of those 3700 had cardiac problems
- 64% chest wall pain—musculoskeletal
- cardiac tests (EKG, cardiac ECHO, Holter, stress test) rarely useful

Chest Pain

- EKG and Holter monitor only ones helpful if arrhythmias/extra beats found on PE
- most common diagnoses in Cardiology clinic study for patients with chest pain: myocarditis, pericarditis, hypertrophic cardiomyopathy, anomalous coronary artery disease
- myocarditis and pericarditis usually present in ERs

Overall Summary

- chest pain rarely a marker for cardiac disease or sudden cardiac arrest
- EKG most useful as screening tool—low yield, but inexpensive
- cardiac ECHO indicated if chest pain associated with exercise
- arrhythmias don’t present with chest pain
Palpitations

- rare cardiac causes
- typical benign history-occur at rest, not with exercise
- stops suddenly with forceful extra beat
- causes include beta agonists (albuterol for asthma), out of shape, parental perception

Palpitations

- exam usually not helpful
- EKG for Wolff-Parkinson-White or possible prolonged QT
- screen for anemia and high thyroid
- EKG while having palpitations key-24 hour Holter, event monitor, or prolonged ambulatory monitor over time-still hard to pick up

Syncope (fainting)

- usually not serious- usually not dangerous
- usually vasovagal (autonomic)
- vasovagal-awareness that going to faint, can have nausea, tunnel vision, usually don’t fall to ground
- usually in hot, stuffy environments-standing-unpleasant
Syncope
- no urination, seizure, no resuscitation
- not during swimming-rare while bike-riding
- usually paleness and sweating observed
- quick recovery

- red flags-injury while fainting, fainting at peak exercise
- red flags-also-no memory of event, passing urine, seizure
- testing needed if family history of sudden, unexpected death or seizures, children with defibrillators, pacemakers
- EKG and QT interval measurements, left ventricular hypertrophy-? ECHO of heart

- Refer if history not consistent with vasovagal syncope
- can order EKG for reassurance
- restrict activities if concerning signs/symptoms
- stress test not useful in children
Commotio Cordis

- almost uniformly fatal—very rare
- follows blunt non-penetrating trauma to chest (baseball, hockey puck)
- may be innocent-appearing playground or home injuries
- immediate ventricular fibrillation without identifiable cardiac trauma

• death from ventricular fibrillation unresponsive to resuscitation
• immediate defibrillation should reverse
• blunt trauma hits at point in cardiac conduction cycle when vulnerable
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C. Chest Pain, Palpitations, Syncope

THANK YOU

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