March 2014 Case Study

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CC: spine fractures

HPI:
16-year-old female high school lacrosse player presented to sports medicine clinic 6 weeks after suffering a back injury while weight lifting. She was participating in off-season strengthening, performing multiple repetitions of high weight. At the time of injury she was squatting 109 kg (240 pounds) and the bar slipped. She felt as though her back went into hyperextension, and she experienced sudden onset of severe pain and difficulty breathing. She was transported by ambulance to a nearby hospital where x-rays and CT scan showed compression fractures of T11 and T12, and right facet fracture at T10-11. She was initially placed in a rigid orthotic back brace and given acetaminophen and hydrocodone for pain. On follow-up with neurosurgery, she was transitioned to a warm and form thoracic and lumbar soft orthotic back brace.

At that time she was referred to sports medicine clinic for evaluation of underlying conditions that may have contributed to her fractures. Her menstrual history revealed onset of menses at age 13, and irregular cycles from the onset. She reported having one menstrual cycle every 2 to 3 months until age 15 when she was put on oral contraceptive pills (OCPs) for one year. She had monthly cycles while on OCPs. Prior to this injury, she had been off birth control pills for 6 months, with return of irregular cycles. Her last cycle was over two months prior to her visit.

Her dietary history was unremarkable. She denied special diets or food restrictions. She denied food intolerances, abdominal pain, diarrhea, or constipation. She denied a family history of osteoporosis, celiac disease, IBD/Crohn’s or other GI conditions. She did not report taking dietary supplements or vitamins.

Training history was significant for an off-season strength program with heavy, maximal weight lifts done in multiple sets and repetitions. Furthermore, she was completing extremely highly weighted squats without appropriate guidance or assistance.

Past medical history revealed exercise-induced asthma and one prior fracture, a Salter Harris I distal fibular fracture with a traumatic inversion ankle injury, several years earlier.

Physical Exam:
Height: 157.5 cm
Weight: 58.4 kg
BMI: 23.5 kg/cm²

GENERAL: Alert and oriented, well-appearing and well-nourished and hydrated, no acute distress.
MUSCULOSKELETAL EXAM OF BACK:
Inspection: No bruising, discoloration or gross bony abnormality.
Palpation: Mild tenderness in the lower thoracic spine on palpation of the spinous processes.
No paraspinous muscular tenderness.
ROM: Out of brace: approximately 20-25 degrees of painless flexion, 10-15 degrees of painless extension, and negative stork testing.
Provocative tests: Negative straight leg raise and FABER testing bilaterally.
NEUROLOGIC EXAM:
Strength: 5/5 bilaterally with hip flexion, knee flexion and extension, and ankle dorsiflexion and plantar flexion. 5/5 strength on extensor hallucis longus (EHL) and flexor hallucis longus (FHL) testing.
Reflexes: 2/4 patellar and achilles deep tendon reflexes.
Sensation: Intact symmetrically to light touch
GAIT: Nonantalgic gait.
VASCULAR: 2+ dorsalis pedis pulses with capillary refill <2 seconds, and no edema.
NECK: Soft and supple, no thyromegaly or thyroid nodules
LYMPHATIC: No lymphadenopathy
SKIN: Intact with no lesions or rashes. Hair and nails without obvious abnormality.

Differential Diagnosis:
Vertebral body burst fractures in the setting of:
• Female Athlete Triad: low energy availability with or without an eating disorder, menstrual dysfunction, low bone mineral density (BMD)
• Vitamin D deficiency
• Polycystic ovarian syndrome
• Hypocalcemia
• Malabsorption: celiac disease, laxative use
• Excessive intake of caffeine
• Hyperparathyroidism
• Overtraining/Improper training
• Osteogenesis imperfecta (type I or III)

Imaging:
CT scan of thoracic and lumbar spine showed:
1. Anterior compression fractures at T11 and T12
2. Right facet fracture at T10-T11
3. Spinous process tip avulsion fractures at T9 and T10
4. Possible mild disc bulge at T11-T12

Image 1: Sagittal view CT scan, Compression Fractures of T11 and T12
Consultations:
Consultation with an endocrine trained sports medicine physician resulted in a work-up for metabolic and endocrine causes. With such a serious injury, and a history of oligomenorrhea, she initially was evaluated with DXA scan to assess BMD and sent for routine blood work.

DXA revealed total hip Z-score of 0.5, and a lumbar spine Z-score of 0.9, thus her BMD was within a normal range.

Lab work was ordered for hormonal and nutritional evaluation, but was never completed. The labs ordered included LH, FSH, total testosterone, SHBG, 17-OH progesterone, DHEAS, TSH, free T4, prolactin, Complete Blood Count, Complete Metabolic Panel with albumin, calcium, phosphorous, magnesium, parathyroid hormone, and 25-OH vitamin D (1).
Diagnosis:
Spinal compression fracture in the setting of overtraining/improper training with irregular menstrual cycles and normal BMD.

Treatment & Recommendations:
The vertebral body compression and burst fractures were treated with bracing, and she has continued to be followed by neurosurgery. She was kept from physical activities until pain-free in the stabilization brace, at which point she was then permitted to begin low-intensity aerobic conditioning, such as stationary cycling. She has been withheld from contact sports for an anticipated three months to stabilize and heal fractures, and will likely be healed in time to participate in spring season lacrosse. Further recommendations and ultimate release back to contact sports are anticipated from neurosurgery.

Dietary recommendations for calcium and vitamin D were provided. 1300 mg of calcium, divided into three daily doses for an adolescent (1000 mg divided into two daily doses for adults) was recommended in the form of supplements or preferably food. The intestinal tract can absorb up to 500 mg at one time, and vitamin C can enhance absorption. Assuming she is not significantly vitamin D deficient, she was advised to supplement with 800-1000 IU of vitamin D daily to enhance bone healing. Further recommendations of vitamin D are anticipated after obtaining lab findings.

Discussion:

Compressive forces secondary to a direct axial load can result in compression fractures or burst fractures. Compression fractures are classified in stages 1 through 5:\(^2\):

- **Stage 1**: simple rounding of the anterior superior vertebral body
- **Stage 2**: more compression than Stage 1 with a beaked appearance noted at the anterior region of the vertebrae
- **Stage 3**: anterior inferior teardrop fracture with displacement
- **Stage 4 and 5**: teardrop fracture as in Stage 3 with a greater degree of displacement

Identification of fracture and fracture staging can be demonstrated on a lateral radiograph\(^2\). Computed tomography (CT) may better define the extent of the fracture. For Stage 3 fractures and above Magnetic Resonance Image (MRI) may help determine the extent of vertebral disc involvement.

Burst fractures are less stable fractures because they involve fractures of the anterior and posterior arches. Their unstable nature raises concern of neurological or vascular compromise. Fracture fragments can be displaced centrally, towards the spinal cord, resulting in catastrophic injuries.

There are fewer neurological concerns when the burst fracture is noted in the thoracic spine\(^2\). Thoracic vertebral compression fractures are typically the result of axial loading of the spine in a flexed position\(^2\). D’Hemecourt et al wrote, if a thoracic compression fracture results in less than 25% loss of vertebral height, the fracture is usually stable. However, if the fracture results in a 50% loss of vertebral height the involvement of the posterior arch should be assessed with a CT scan and/or MRI if there are neurological symptoms, even if they are transient\(^2\).

A flexion distraction type injury will result in posterior element ligamentous disruption and widening of the spinous processes as seen in this case.
Treatment of minimal compression fractures without posterior arch involvement, as in our case, can be performed by immobilization in a thoracolumbar orthosis (TLSO) for 6-12 weeks until pain free (2).

Return to sports should be delayed until the bracing period has been completed. The athlete should also have regained full range of motion and strength comparable to that prior to injury. Attention should be given to strengthening posterior elements of the spine with extension-based exercises. Athletes with minimal compression fractures and no neurological deficits may return to contact sports when full range of motion and strength has been regained (2). More severe fractures with neurological involvement may result in withdrawal from future contact sports.

Prevention of this type of injury, particularly burst fractures of the cervical spine, is paramount. Teaching proper technique, such as maintaining a heads up posture in hockey and discouraging spear tackling in football, may be helpful in reducing this type of problem (2).

Low bone density predisposes people of all ages to spinal compression fractures, and athletes in particular to bony stress reactions or fractures. Low BMD is rare in young, healthy individuals. In pre-menopausal women and younger men these injuries can be explored in a stepwise fashion to help identify underlying contributions from genetic, nutritional and hormonal factors.

Typical evaluation begins with personal and family medical history and physical exam. History of previous stress injuries or atraumatic fractures, or family history of osteoporosis provides insight about genetic conditions, including the milder forms of osteogenesis imperfecta (1). Nutritional history, such as diets, food avoidance, weight loss, caffeine consumption may also provide insight into factors worth exploring that would also cause low BMD. GI disorders, such as celiac disease, or chronic diarrhea with Crohn’s may also lead to malabsorption and thus potential problems such as vitamin D deficiency.

Polycystic ovarian syndrome (PCOS) may explain this patient’s oligomenorrhea, but is less likely to lead to low BMD, as many patients with PCOS have elevated androgens, which are converted to estradiol, a bone anti-resorptive. Features of PCOS that may be revealed on history or exam include irregular cycles, increased body weight, and signs of hyperandrogenism (e.g. acne and hirsutism).

The Female Athlete Triad (Triad), or low BMD in the setting of low energy availability and menstrual irregularity, has become a common cause of stress injury in many of our weight-restricted and aesthetic sports, such as running, figure skating, lightweight rowing, and dance (1). Stress fractures occur two to four times more commonly in physically active women with menstrual irregularities and/or low BMD (1). A thorough history may reveal characteristics concerning for Triad before or after developing stress injuries. If discovered, evaluation of bone health and treatment with nutritional and training modifications, often in addition to psychological counseling, would be further justified (1).

A thorough menstrual history is valuable for providing insight into the functioning of the hypothalamic-pituitary-ovarian axis. Low energy availability and other causes of hypogonadism lead to poor bone mass accretion. Bone mass accretion is substantial during adolescent years. DXA tests are only two-dimensional assessments of BMD and cannot assess bone microarchitecture or quality. However, currently DXA is our best clinical tool for BMD assessment (1).

For young women with oligomenorrhea and decreased bone density, estrogen and progesterone in birth control pills can provide menstrual regularity. However, such pills have negative feedback to other hormones important for bone metabolism, such as IGF-1, and the
pills only mimic a normal menstrual cycle. They cannot replicate the normal pulsatility patterns and the interplay between many hormonal pathways building and protecting bone \(^1\). There is a paucity of research supporting oral contraceptive benefits on bone health in athletes. Therefore finding and treating the cause of the oligomenorrhea is paramount.

After reviewing initial screening blood work, additional lab evaluations may be ordered to rule out predisposing risk factors for fracture. To help assess proper hypothalamic-pituitary functioning, laboratory evaluation includes prolactin, FSH, LH, TSH and free T4. If signs of hyperandrogenism are present and/or PCOS is suspected, levels of total testosterone, SHBG, 17-OH progesterone, DHEAS should be measured, too. Complete metabolic panel plus albumin can be tested to assess overall nutritional status. Calcium, phosphorous, magnesium, and 25-OH vitamin D, and PTH can assess possible disorders of mineral metabolism \(^1\). Complete Blood Count is important in evaluating the overall health of the patient and checking for anemia. Bone turnover markers such as bone-specific alkaline phosphatase, osteocalcin, procollagen type-1 N-terminal propeptide (P1NP), and carboxy-terminal collagen crosslinks (CTX) are not useful as low bone density screening tools, particularly in the setting of fracture healing.

One ultimate cause of our patient’s compression fractures appears to be training error. This raises questions regarding the appropriateness and methods of weight training in young populations. Coaches and athletes should remember the goals of weight training as they pertain to their sport and remember that full skeletal maturity has not yet been reached in most adolescents. The latest recommendations regarding pediatric and adolescent resistance training include the American Academy of Pediatrics’ position statement (2008), and most recently the International Consensus Statement on youth resistance training (2013) \(^3,4\).

Before starting a resistance-training program, a pediatric athlete should be able to show a confident level of proficiency in the sport to help establish specific goals of weight training. Proper technique and safety precautions should be followed to assure such training is safe and effective. Additionally, preadolescents and adolescents should avoid power lifting, bodybuilding, and maximal lifts until they reach physical and skeletal maturity. Lighter weight with higher repetition may be appropriate for the skeletally immature.

When physicians are asked to recommend or evaluate strength-training programs for children and adolescents who show specific sport proficiency, the following issues should also be considered \(^3,4\):

- Children with complex congenital cardiac disease (cardiomyopathy, pulmonary artery hypertension, or Marfan syndrome etc.) should have a consultation with a pediatric cardiologist before beginning a strength-training program. Precaution should also be taken with athletes with hypertension.
- Youth who participate in activities that enhance muscle strength and motor skills early in life may be at decreased risk for negative health outcomes later in life.
- A general strengthening program should address all major muscle groups, including the core, and all exercises should be completed through the full range of motion of each joint. Sport-specific training may be subsequently added, after developing proficiency. Strength-training programs may reduce sport-specific injuries and should be viewed as an essential component of preparation.
- Specific strength-training exercises should be learned initially with no load (no resistance). Once the exercise technique has been mastered, incremental loads can be added using either body weight or other forms of resistance. Strength training should involve two to three sets of higher repetitions (eight to 15) two to three times per week and be at least eight weeks in duration.
• Strength-training programs should include a 10- to 15-minute warm-up and cool-down.
• Athletes should have adequate intake of fluids and proper nutrition, because both are vital to the maintenance of muscle energy stores, recovery, and performance. The recommended energy availability of fat-free mass per day is greater than 30 kcal/kg \(^{(1)}\).
• Proper technique and strict supervision by a qualified instructor are critical safety components in any strength-training program involving preadolescents and adolescents. Instructors or personal trainers should have certification reflecting specific qualifications in pediatric strength training.

References: