Motocross Medicine

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GRANGE, J.T., J.A. BODNAR, and S.W. CORBETT. Motocross medicine. *Curr. Sports Med. Rep.*, Vol. 8, No. 3, pp. 125–130, 2009. *Motocross is an increasingly popular but high-risk sport. This article reviews the history of motocross, the relevant medical literature, the unique medical issues, safety equipment, and the expert recommended approach to providing support for such events. Assessment of an injured rider on or near a track requires a provider to first ensure scene safety, then assess for airway, cervical spine, and head injuries before proceeding. Although extremity injuries are the most common injury, motocross riders frequently sustain significant spine and head trauma as well. Caregivers need to have a complete understanding of the protective gear used in motocross. They also need to be able to understand what injuries can be treated at the scene and which need transport to a hospital for more definitive care.*

INTRODUCTION

Ernest Hemingway reportedly stated, "There are only three sports: bullfighting, motor racing, and mountaineering; all the rest are merely games." This comment may have been made at least partially because of the high risk of significant injury and even death from these pursuits when compared with the typical "stick and ball" sports. This article reviews the history of motocross, the relevant medical literature, the unique medical issues, safety equipment, and the expert recommended approach to providing support for such events.

Motorcycle racing is generally divided into on-road and off-road. When it comes to off-road motorcycle racing, there are a number of variations of the sport, including the following: motocross, supercross, flat track, supermoto, hillclimb, trials, desert racing, and ATV motocross. This article will focus upon motocross motorcycle racing, which takes place outdoors on a course that combines natural terrain with some human-made obstacles (steep inclines, hairpin turns, jumps, sand, and mud). Supercross motorcycle racing is a variation of motocross that has evolved for the more urban environment and takes place inside stadiums on human-made tracks. Supercross tracks tend to be shorter courses but also tend to have tighter turns and higher jumps because of the limited space inside stadiums.

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HISTORY OF MOTOCROSS

Motocross (frequently abbreviated as MX) originated in England in 1924 with bicycles with small internal combustion engines attached. A 2.5-mile course was made that included bogs, hills, rocky sections, stream crossings, and other "natural terrain." Of the 80 contestants entering the world's first motocross race, only 40 finished (26). Motocross continued to evolve and became increasingly popular throughout the middle of the 20th century. The first time that a motorcycle race took place on a human-made course inside a stadium was in 1948 at Buffalo Stadium in the Paris suburb of Montrouge. The course included jumps on the straights, switch-backs in the turns, and a steeplechase-type water hazard. In 1969, ABC Wide World of Sports broadcast the first motorcycle race in Pepperell, Massachusetts. In 1972, rock concert promoter Mike Goodwin debuted motocross racing in front of 28,000 fans at the legendary Los Angeles Coliseum during the first "Superbowl of Motocross." The "Super Bowl of Motocross" was later shortened to Supercross.

The motorcycles themselves also evolved across this time. Innovations such as swingarm suspensions, fuel injection, disc brakes, and liquid-cooled engines allow machines weighing less than 225 lb to generate over 50 horsepower. These motorcycles are capable of attaining speeds of over 100 mph and sailing over 100 ft off jumps. When racers take these onto a crowded racetrack over rough and broken terrain, accidents are inevitable.

MEDICAL LITERATURE REVIEW

The National Highway Traffic and Safety Administration (NHTSA) reports that 4810 motorcyclists were killed in 2006. During this same time, NHTSA reports 88,000

motorcyclists injured. Per vehicle mile traveled in 2005, motorcyclists were approximately 37 times more likely than passenger car occupants to die in a motor vehicle crash and 8 times more likely to be injured (15). It is important to emphasize, however, that these statistics generally refer to on-road motorcycle injuries. Although off-road motorcyclists have been documented to have a lower risk of injury and death compared with on-road motorcyclists (16), until recently, little data were available specific to motorcycle racing injuries during competition.

Tomida *et al.* (24) described the incidence and pattern of injuries among elite motorcycle competitors in Japan. Their sample compared 36 road racers to 60 motocross racers and 21 trial bike riders. They reported an overall injury rate of 22.4 per 1000 h of motorcycle riding. Interestingly, they demonstrated that motocross had a 21.4 higher relative risk and that road racing had a 15.5 times higher relative risk of injury than trial biking, suggesting that among professional racers, motocross had the highest risk of injury. Tomida *et al.* also confirmed that injury rates during motocross practice sessions were noticeably higher than during actual races! This important finding is confirmed by the authors' experience and should be considered when providing medical support for the higher risk but frequently lower profile testing/practice sessions.

Gobbi *et al.* (13) analyzed motocross injuries in a series of competitions in Europe over a 12-yr period from 1980 to 1991. They evaluated 1500 accidents with 1870 injuries in athletes participating in European motocross and found the incidence of accidents to be 22.7 per 1000 h ridden (with an average of 4.5 accidents per race). This injury rate is amazingly similar to that reported in the Japanese study described previously and seems consistent with the authors' experience in the United States. When compared with other sports, they found that motocross had the highest incidence of injuries second only to motorcycle road races. Injuries were categorized as upper extremity (36%), lower extremity (36%), face (9%), skull (1%), head (5%), chest (13%), and spine (1%). Head injuries were more common in motorcycle road racing, while neck fractures were more common in motocross. Overall, spine fractures comprised 5.8% of all fractures, with nearly one third of these having permanent neurologic sequelae! These researchers also reported that there were 146 riders with ligamentous knee injuries. Seventy-two percent of the injured riders wore knee pads, while 27% of those injured wore special knee braces. Although the total numbers of riders wearing each protective device isn't reported, the authors strongly encourage the use of specialized knee braces in all motocross competitions.

Several articles (10,14,22) reported on the increasing incidence of motocross injuries and their injury patterns while other articles measured the human body's physiological response to motocross racing (2,3,12,19,20). Finally, several reports discussed significant traumatic injuries such as aortic injuries and bilateral ankle fractures (5,6,18,25).

GENERAL MANAGEMENT OF INJURIES

Most motocross injuries involve fractures or ligamentous damage to the upper or lower extremities. However, approximately 10% of motocross injuries (7) involve potentially life-threatening head and/or neck injuries or other significant trauma. Because of the significant morbidity and mortality and significant frequency of airway, head, and neck injuries, they are always the first priority when caring for a motocross rider. For the same reason, the minimum recommended level of care at all motocross events is an advanced life-support ambulance crew with additional training regarding track operations and motorsports medicine.

Even before providing the usual ABCs of trauma, the first consideration must be scene safety. Scene safety starts with advance planning with track managers and security. Specially designated access points that are free of spectators will allow responders to arrive at the scene of an accident quickly and safely. Responders may need to carry wire cutters if they will need to pass through fence sections secured with plastic strip ties or baling wire. Spotters with radios (in a tower or other vantage point) can dispatch responders to downed riders not immediately visible. Flaggers also can alert medical crews to downed riders by waving yellow flags. This is especially important because racers often crash in areas that are hidden to the view of oncoming riders such as the downhill side of a jump or around a tight corner. In these cases, the flaggers also can direct traffic to the side of the track away from the accident. Dirt and debris can be sprayed from the wheels of passing racers so protective eye wear is recommended. Sometimes, mini-emergency response vehicles are used to protect the injured rider and caregivers (Fig. 1). Although practice sessions and certain events may be stopped to provide necessary medical assistance, frequently care must be provided on a "hot track" with other competitors still racing by in order to provide appropriate care in a timely manner.

After ensuring that the scene is safe for both the rider and themselves, caregivers should then focus on the ABCs of advanced life support. As the caregiver approaches the

Figure 1. A miniature off-road ambulance is used to transport riders from the track.

rider, specific attention to minimizing any neck movement by approaching the rider "face on" should be considered. This will minimize the chance that the rider will turn his head to see you or answer your questions and exacerbate an unstable injury. For the unconscious motorcycle rider it is ideal if the race can be stopped to ensure the safety of everyone. Unfortunately, this is often logistically time consuming and not always feasible. The unconscious motocross rider thus requires caregivers to provide basic airway and spinal stabilization with emergent transport off of the hot track to a safe area where more advanced life-support procedures can be initiated. Although occasionally still debated, most experts recommend immediate removal of the helmet in order to better access the airway and to be able to place the rider on a backboard in appropriate spinal alignment with immobilization. Helmet removal must be performed carefully with at least two providers, one providing inline immobilization of the spine from below while the other opens the helmet and removes it from above. Rotation and traction of the spine must not occur. Some helmets are equipped with helmet removal systems. These have an air bladder inside the helmet that can be inflated from the outside by the caregiver. When pumped full of air, the bladder forces the helmet off the head while pushing down on the vertex of the skull. Providers must carry an inflator bulb to use this feature. It should be noted that brief episodes of unconsciousness are quite common in motocross and have never been shown to be predictors of significant head injury. An unconscious motocross rider frequently only requires basic airway maneuvers such as a jaw thrust which can be easily done while a rider is still helmeted with his neck stabilized. Frequently, within about 1–2 min, these riders wake up with normal neurological exams and refuse any further care, although transport to a hospital for evaluation is generally recommended for these patients.

In the conscious motocross rider, the authors recommend the FAST exam when on a hot track. FAST is an acronym that stands for F: first safety, then A: airway, S: spine, and T: thinking. In general the FAST exam can be done in less than 60 sec to determine whether someone can be walked or assisted off the track versus having to provide full spinal immobilization before being moved. Upon approaching the conscious rider, a simple question such as "Are you OK?" will tell you if the patient has an adequate airway. The rider should then be asked regarding a possible neck injury while spinal immobilization is maintained. For example, one should ask, "Do you have any neck pain? Any numbness/tingling? Any weakness?" It should be remembered, however, that guidelines for clearing cervical spines in the absence of radiographs (17,23) were never intended to be used in the prehospital motorsports environment. The authors have witnessed numerous unstable cervical fractures without any neck pain initially upon arrival at crash scenes at various motorsports events. This is believed to be due to the much shorter time interval between the incident and patient assessment compared with that in the emergency department when there has been time for the adrenaline to subside and for swelling to take place in order to have pain from acute fractures. Thinking should also be assessed in a rapid manner since you are on a hot track. Although a full neurological exam would be ideal, the time limitations require an abbreviated exam. Because previous research has shown that orientation is not a predictor of significant head injury, the authors recommend asking, "What happened?" in addition to the usual orientation questions. Retrograde amnesia has been shown to be the best predictor of significant head injury in motor sports. Thus the failure of a rider to be able to adequately report what happened just before and during the crash requires that the patient be placed in spinal immobilization before being moved off the hot track for a higher level of evaluation and care.

Once motocross riders are off the hot track and in a safe area, a more thorough yet focused history and physical exam should be conducted. All motocross riders who have any evidence of a head or neck injury should be transported immediately to the nearest appropriate emergency department and/or trauma center (when available) for a higher level of evaluation and care than typically is available in the prehospital environment. Although motocross riders with extremity injuries also should go to the hospital for imaging and further care, there are certain exceptions. For instance, at the higher levels of motocross competition, some organizations now have board-certified, emergency physician-staffed facilities available at the motocross track. Examples of these facilities include the Asterisk Mobile Medical Center and the Loma Linda University Medical Center Mobile Telemedicine Vehicle (MTV). The Asterisk Mobile Medical Center has a complete medical staff with a physician, registered nurse, and athletic trainer, as well as x-ray ability, supplies, and equipment to render both emergent and nonemergent medical care to competitors and their staff. The MTV has x-ray capabilities with real-time satellite-based telemedicine capabilities that allow a "virtual physician" to be present at the motocross track even when one may not be physically able to attend. These specialized medical facilities also frequently are equipped with mobile off-road capable mini-ambulances that are able to respond on the motocross track and provide advanced life support while transporting

Figure 2. Mini off-road ambulance by Mobile Telemedicine Vehicle (MTV) at Glen Helen Raceway.

Figure 3. Motocross racer jumping in front of Mobile Telemedicine Vehicle (MTV).

immobilized patients back to the main facility or to an ambulance or helicopter for transport to a hospital. These customized mini emergency response vehicles also frequently are equipped with lights and sirens, communications equipment, backboards, oxygen, defibrillators, and other medical gear (Figs. 2 and 3).

CONCUSSION

Concussion is one of the most common serious injuries encountered in motocross riders. Although there is no universally accepted definition for concussion, the American Academy of Neurology defined concussion in 1997 as "Any trauma induced alteration in mental status that may or may not include a loss of consciousness" (1).

The diagnosis of concussion can be challenging under the best of circumstances. It is particularly difficult at the motocross track, however, since the concussed rider may not be aware that he or she has been injured and may not show any obvious signs of injury such as confusion, amnesia, or other alterations in mental status. Many riders also tend to minimize their symptoms and believe that "getting your bell rung" is normal when riding motocross. They may refuse any medical care or transport to the hospital. The Table provides a summary of common track-side signs and symptoms of concussion. Headache is the most commonly reported symptom of concussion (8). It is important to realize that riders present very differently with regard to their signs and symptoms, and many concussions are quite subtle in presentation. Confusion and amnesia are much more common than loss of consciousness with trauma to the head.

Any patient with signs or symptoms of concussion after a significant impact should be transported to an emergency department for observation and possible imaging studies to rule out more serious pathology. Every motocross track should have a plan to immediately transport such patients for a higher level of care and evaluation. Every motocross track and/or organization also should have policies in place to prevent riders with such injuries from continuing to ride because of the risk of further brain injury from an additional head injury.

To assess properly for the presence of confusion, the rider should be asked simple orientation questions (*e.g.,* name, current location or track, day of the week, month). A careful trackside evaluation of amnesia also is extremely important. The presence of posttraumatic amnesia has been found to be highly predictive of post-injury neurocognitive deficits (8). Retrograde amnesia also is an important predictor of concussion severity (11). Retrograde amnesia is defined as the inability to recall events occurring during the period immediately before the trauma. To assess for this, one should ask the rider what happened just before the crash or what caused the crash. Several studies have confirmed the predictive ability of on-track markers for severity of concussion and post-concussive difficulties 3 d post-injury (9). The data from these studies demonstrated that the presence of amnesia, not loss of consciousness, was most predictive of difficulties. Athletes who had retrograde amnesia were found to be more than 10 times more likely to have significant cognitive deficits and/or severe symptoms 3 d after the injury.

Although numerous concussion management guidelines regarding returning to competition have been published over the last 30 yr, the authors recommend following the guidelines published by the Concussion in Sport (CIS) group, which emphasize post-injury neuropsychological testing with a graduated return to play after injury (4,21). Riders should never be allowed to return to competition the same day unless they are completely asymptomatic both at rest and with exertion following a crash.

Although computerized neuropsychological testing has been required in much of motorsports (*e.g.,* NASCAR, Indy Car, CART, Formula One) for a number of years now, the motorcycle racing sanctioning bodies have not required it. In the future, computerized neuropsychological testing may be required before participation in sanctioned motocross competition; however, the lack of outcome studies has prevented most from mandating such until there is better supporting evidence.

TABLE. Common signs and symptoms of concussion.

Signs	Symptoms
Dazed	Headache
Confused	Nausea
Clumsy or unable to remove helmet	Vomiting
Slow to respond	Dizziness
Loss of consciousness	Photophobia
Personality changes	Feels "foggy"
Forgets events before crash (retrograde)	Inability to concentrate
Forgets events after crash (posttraumatic)	Fatigue
Repetitive	Blurred vision or visual changes
Disoriented (person, place, time)	Emotional instability

NECK INJURIES

The most feared injury from motocross is a neck injury with paralysis. Although it is relatively rare (<1%), the increasing popularity of motocross has increased the numbers of patients with such catastrophic injuries. Although it should be self-evident, any riders with neck pain, paresthesias, weakness, or confusion should be assumed to have a neck injury, placed in full spinal immobilization, and transported to a hospital for imaging. There still is no cure for paralysis! Historically, many emergency medical service providers gave high dose IV steroids while en route to the hospital for possible spinal cord injuries. This practice is now generally frowned on because of the lack of supporting evidence and increasing evidence regarding the risks of steroids.

EXTREMITY INJURIES

The most common injuries from motocross involve the upper and/or lower extremities. Fractures of the tibia, fibula, radius, ulna, and humerus are considered by many riders to be commonly accepted (and expected) risks of the sport. Caregivers should be aware that wrist injuries commonly are encountered following both falls on the outstretched hand and during "hard landings" often without an associated "crash." When evaluating wrist injuries at the track, it is important to evaluate for "snuff box" tenderness due to the significant risk of occult scaphoid fractures in motocross. Care of extremity injuries should follow standard basic trauma life support guidelines with appropriate splinting, pain control, and transfer to the emergency department for imaging studies and follow-up.

ARM PUMP

Motocross riders frequently complain of "arm pump," which also is known as chronic exertional compartment syndrome (CECS) after "hard riding." Many riders report a sensation of tightness in their forearms and weakness in their hands, which prevents them from continuing to ride or can cause them to crash. In its severe form, riders report severe pain and weakness with an inability to grip the handlebars at all. Unlike the typical acute compartment syndrome, which usually is caused by trauma, the pathophysiology of chronic exertional compartment syndrome is unclear. Many hypothesize, however, that it is related to increased blood flow to the muscles in the forearm combined with relatively decreased venous outflow. Many report an increased incidence of "arm pump" when they grip the handlebars too tight, are deconditioned, or are dehydrated. Motocross riders have tried numerous remedies including altering riding styles, various stretches, weight training, aspirin, acupuncture, magnetic therapy, crystals, and forearm fasciotomy. While forearm fasciotomy remains controversial, it anecdotally seems to have helped at least some riders.

SAFETY EQUIPMENT

Safety equipment for the motocross rider has continued to evolve. The most important piece of safety equipment for any motorcycle rider is his or her helmet. The data regarding helmet use in motorcycle riders are overwhelming and will not be reviewed here since little controversy exists regarding the absolute need to wear a helmet and the decrease in morbidity and mortality from doing so. Motocross helmets should include face protection from dirt and gravel thrown up from the track. Other safety equipment for any motocross rider should include boots, gloves, elbow pads, pants, chest protector, kidney belt, goggles, and knee braces.

A number of companies now are selling neck braces for motocross riders that are marketed as being able to prevent serious neck injuries. Each version of neck brace is designed to sit on the rider's shoulders and limit the extreme range of movement of the helmeted head during a crash. Unlike neck restraints in four-wheeled motorsports, the braces designed for motocross are not connected to the helmet in any way. Instead, they provide a solid surface to stop helmet motion, thus hopefully preventing damage to your vertebra and spinal cord from extreme forward, rearward, lateral, or compression forces. No research is currently available to determine whether the currently available neck braces reduce serious neck injuries or not. Because the authors have seen unstable neck fractures in riders with some of the most common neck braces mentioned, it is even possible that the neck braces could exacerbate certain types of motions and increase the risk of some injuries. As use of these devices becomes more popular, we will get a clearer picture of what kind of benefit they offer.

CONCLUSION

Motocross is a high-risk sport with head, neck, and airway issues as the primary medical concerns. The minimum level of care recommended during all motocross events is an advanced life-support ambulance. Future research should evaluate the efficacy of various types of safety equipment.

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