



Association of Ringside Physicians

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Editor-in-Chief, Editorial Board



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From the Editor's Desk

Dear Colleagues,

It gives me great pleasure to bring to you Volume 4 issue 1 of the *ARP Journal of Combat Sports Medicine*. Combat sports events have slowly resumed with fans in attendance in arenas across the country as well as around the world. In crowded areas, locker rooms, and gyms the risk of COVID-19 transmission though remains, and we should encourage athletes, coaches, trainers, cut men, referees, judges, promoters, production staff, commission staff, and our colleagues to get vaccinated unless there is a valid medical or religious exemption.

We had a very successful Annual Conference in Las Vegas in September 2021. The Conference was well attended, and all the lectures were appreciated by the attendees. It was a pleasure to meet many of you in person and get to know each other better.

The highlight of this issue is the **Mouth Guard Use in Combat Sports Position Statement from the Association of Ringside Physicians**. The position statement was drafted by Drs. deWeber, Hindagolla and Muzzi and is collaborative effort of the authors in conjunction with the Association of Ringside Physicians (ARP) Board of Directors, Emeritus Board, and some subject matter experts. In its position statement, the Association of Ringside Physicians recommends that mouth guards be used in all high- and intermediate-risk sports, including contact and combat sports, to aid in the prevention of orofacial trauma. Custom mouth guards made by a skilled, qualified dentist are highly recommended over stock mouth guards or boil-and-bite mouth guards. ARP does not endorse over-the-counter “stock” or boil-and-bite mouth guards.

Celebrity boxing and MMA events are becoming more common and older boxers are coming out of retirement to showcase their skills once again under the bright lights of the ring. There are two commentaries (**Celebrity boxing, aged fighters-medical ramifications and Too old to box-should there be a mandatory retirement age in boxing?**) that dwell on the medical ramifications of allowing such fights to take place.

Establishing a **national medical database** in boxing is the need of the hour. Such a database would not only streamline the process of review of medicals prior to a fight, it shall also go a long way in protecting health and enhancing safety of boxers making the sport safer and better medically supervised by standardizing medical requirements across various commissions.

Two protocols are presented one detailing a **standardized post-fight medical evaluation and the second a standardized post-concussion return to boxing**.

A short case series on **traumatic tympanic membrane perforation in boxing** is presented. Finally, a commentary on **incidentally detected arachnoid cysts in boxers** is presented and a discussion on how to approach this radiological finding follows. I trust you shall find the consensus statement, commentaries, protocols, and case series interesting and educational.

The journal would not be possible without hard work and dedication of our two Senior Editorial Managers, Lisa Nelson and Susan Rees. They continue to work tirelessly to improve the journal and make it a valuable resource for the combat sports community.

The *ARP Journal of Combat Sports Medicine* is actively soliciting case reports, case series, review articles and original studies related to the field of combat sports medicine. Please consider the journal for publication of your valuable work.

I wish you and your families good health and happiness.

Sincerely,

Nitin K Sethi, MD, MBBS, FAAN

CORRECTION: In Volume 3, Issue 2, Dr. Victor Khabie's name was incorrectly spelled in the article, "Transgender Athletes in Combat Sports: To Fight or Not to Fight." The editors of the *Journal of Combat Sports Medicine* apologize for this error.

Mouth Guard Use in Combat Sports. A Position Statement from the Association of Ringside Physicians

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Position Statement

Based on the available data, the Association of Ringside Physicians recommends that mouth guards should be used in all high- and intermediate-risk sports, including contact and combat sports, to aid in the prevention of orofacial trauma. Mouth guards are proven to reduce the risk of orofacial trauma in contact sports. They should be worn during all sparring, grappling, and competition. Custom mouth guards made by a skilled, qualified dentist are highly recommended over stock mouth guards or boil-and-bite mouth guards. APR does not endorse over-the-counter “stock” or boil-and-bite mouth guards. Custom mouth guards provide more complete coverage of teeth and molars, fit more comfortably, remain in place better, have fewer side effects, and do not degrade athletic performance. Effective education on appropriate mouth guard use should be provided to all athletes participating in these sports.

Preamble: Development of this Statement

This position statement expresses a collaborative effort among the Association of Ringside Physicians (ARP) Board of Directors, emeritus Board, and some subject matter experts. An extensive literature search including but not restricted to

MEDLINE, Cochrane Reviews, and non-indexed peer-reviewed articles published in online medical journals was performed regarding combat sports, contact sports, and mouth guards. Unfortunately, significant studies/articles/information in combat sports regarding mouth guard use are lacking. Hence, much of this statement is an extrapolation of current recommendations on mouth guard use in contact sports with the current best practices in combat sports and the collective expertise and experience of its authors having provided ringside medical coverage over many years.

Definitions

Sports activities in general can increase risk of orofacial trauma. Orofacial trauma includes fractures of facial bones; lip and cheek soft tissue trauma; injuries to the dentition which can include subluxation, avulsion, and fracture; and lacerations of the gum and tongue.¹ In comparison to other soft tissue injuries, orofacial injuries are often more complex, require longer healing time, and can have both financial and psychological impact on affected athletes.

Combat sports are defined as competitive contact sports that generally involve one-on-one unarmed

combat. These include sports such as boxing, taekwondo, judo, karate, wrestling, and many others. A list of combat sports is provided in Table 1.

Mouth guards are defined by the American Society for Testing and Materials as a “resilient device or appliance placed inside the mouth to reduce mouth injuries, particularly to teeth and surrounding structures.” The device separates the upper and lower dentition and protects at least a portion of the teeth from the surrounding soft tissue. They are hypothesized to reduce injury by absorbing or redistributing shock during direct impacts, stabilizing the jaw during traumatic jaw closure, and reducing incidence of bruising and laceration to adjacent soft tissue.³

Design of the mouth guard, including the materials used in construction, is key to its effectiveness in preventing injury. These materials affect the shock absorbing ability, the tensile strength and tear strength, among other important properties.³ The thicker the material, the greater the resultant energy absorption.⁴ Early mouth guards were composed of latex rubber, but this was found to lack shock absorbing quality, as well as tear and tensile strength compared to newer materials. More modern mouth guards are created with a variety of different materials, including ethinyl vinyl acetate, polyurethane, silicon, and other compounds. None of these newer compounds stands out as superior in comparison to the others, as they can all

be manipulated and used in combination to create favorable characteristics in a mouth guard.³

Types of Mouth Guards

The most common types of mouth guards available to athletes are as follows (Figure 1).⁵

- Type I: Stock, or ready-made mouth guards, bought over the counter and designed to be used without further modification.
- Type II: “Boil-and-bite”, or mouth-formed mouth guards, made with thermoplastic material that is immersed in hot water and then formed in the athlete’s mouth using finger, tongue and biting pressure.
- Type III: Custom made mouth guards, based on a model of the athlete’s jaw, and created by a dental professional.

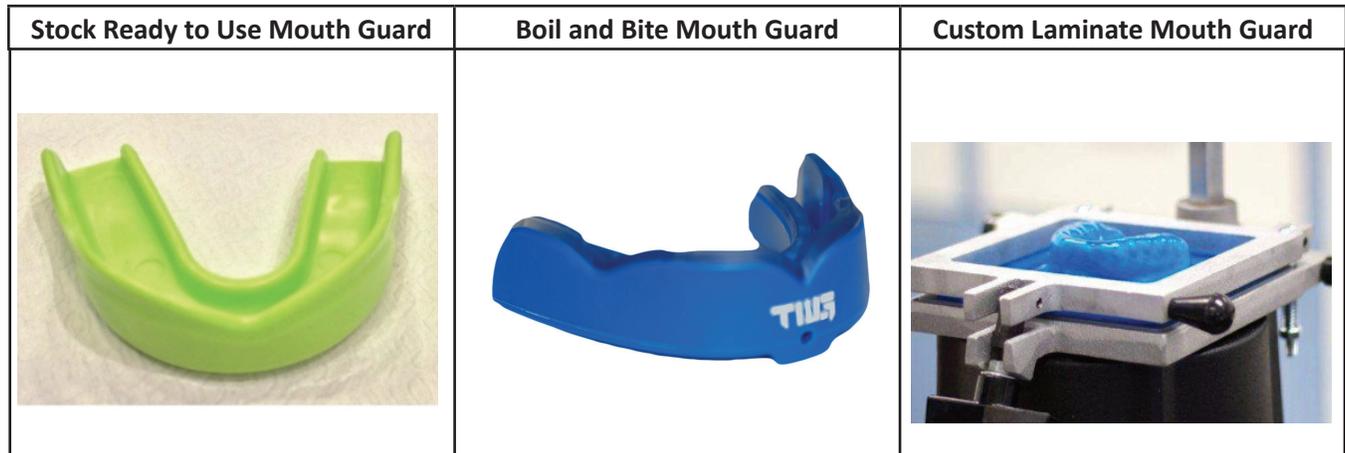
The type I and type II mouth guards are generally bulky and require constant occlusal pressure to be held in place.⁵ During fabrication of these types of mouth guards, thickness decreases from 70 to 99 percent from pre-fabrication thickness.⁴ This can result in the athlete biting through the material during the molding process and thinning the mouth guard, taking away its protective qualities. Sizing is also an issue with these mouth guards. Studies on arch length showed that even with the largest available mouth-formed mouth guards,

TABLE 1: Examples of Combat Sports

Striking Sports	Grappling Sports	Armed Sports
Boxing	Wrestling *	Fencing
Kickboxing	Judo	Kendo
Muy Thai	Jiu-Jitsu	Jousting
Karate	Sumo	Dueling
Taekwondo	Mixed martial arts	

*Many subtypes of wrestling including collegiate/scholastic, Greco-Roman, professional, and for entertainment.

FIGURE 1: Types of Mouth Guards



these would cover the posterior teeth in only 15% of high school and collegiate athletes.⁵

The type III mouth guards allow dentists to address several critical issues in the fitting of the mouth guard, including providing additional protection for specific areas unique to each athlete, and the appropriateness of the design for the sport being played. In review, these types of mouth guards are considered to be more superior to any of the over-the-counter types (I, II) available. However, despite their superiority, there can still be some deficiencies in the mouth guard, depending on the fabrication process. Additionally, some materials used have elastic memory, and over time will lose their fit and retention. Changes in fabrication process have been recently employed (multiple layers of lamination with varying materials) to try to overcome these deficiencies.⁵

The primary role of mouth guards is the protection of the teeth and oral-facial structures. Mouth guards should be primarily designed to accomplish this goal, with adequate protection in the areas most likely to be traumatized (maxillary incisor teeth). A properly fitted mouth guard must be protective, comfortable, resilient, tear resistant, odorless, tasteless, not bulky, cause minimal interference with speaking and breathing, and have excellent retention, fit, and sufficient thickness in critical areas.

Epidemiology of Orofacial Injury in Combat Sports

Combat sports carry a high risk of orofacial trauma when compared to other contact sports.¹ The largest and most recent meta-analysis of dentofacial injury in combat sports found a pooled prevalence of 30%. Rates of prevalence by discipline included jiu-jitsu (52.9%), boxing (45.9%), wrestling (45.9%), karate (43.5%), taekwondo (37.5%) and judo (25.0%). The authors found wide variation in use of mouth guards in this review, with some studies having very high rates of usage and some very low, which confounded the results of injury prevalence.²

Effect of Mouth Guards on Prevalence of Orofacial/Dentofacial Injury

For over 50 years, the American Dental Association (ADA) has promoted the use of mouth guards in athletic activities that carry risk of dentofacial trauma.⁷ Before the development of orofacial protectors (helmets, face shields, mouth guards), the ADA estimated that approximately one-half of injuries sustained by high school football players not wearing any type of face/mouth protection occurred in or around the mouth, and that these injuries could have been prevented with use of orofacial protectors. Through use of orofacial protectors including mouth guards, the preva-

lence of oral trauma has dropped from 50% to about 1%.⁷ In a study involving NCAA basketball players, athletes wearing custom mouth guards sustained fewer injuries (1.16 injuries per 1,000 athletic exposures), compared to those who were not wearing mouth guards (3.00 injuries per 1,000 athletic exposures). The ADA also endorses the benefit of mouth guards in providing protection to athletes undergoing orthodontic treatment. For athletes with fixed orthodontic appliances in place, mouth guards aid in separating the soft tissue from the teeth and preventing intraoral lacerations and bruising.

Since the most recent ADA statement in 2006, empirical data has strengthened the position that mouth guards effectively prevent orofacial trauma in sports. A recent meta-analysis of 12 cohort trials and of 11 self-report trials showed that mouth guard use reduced overall risk of orofacial injuries, with a relative risk ratio of 2.32 (12). Four of the studies included combat sports athletes among other contact sport athletes, and one (13) involved only boxing and taekwondo athletes. It showed a dental trauma incidence of 12.6% in mouth guard users and 25.8% in non-mouth guard users. Another recent meta-analysis of four controlled studies in contact sports athletes showed a markedly decreased prevalence of dento-alveolar trauma in athletes wearing mouth guards (7.5%) compared to those not wearing mouth guards (59.5%).⁸ The four studies analyzed only included one with combat sports athletes (Swiss boxers).⁹ A retrospective study of several hundred US military recruits participating in hand-to-hand combat training showed that the risk of orofacial injury was reduced by a ratio of 1.76 after mouth guards were required compared to when they were not used. This study used boil-and-bite mouth guards that were fitted by dental professionals.¹⁰

Effect of Mouth Guards On Sport Concussion

Mouth guard use has a theoretical protective effect on the brain by positioning the jaw in an optimal way to absorb impact forces that might otherwise be transmitted through the base of the

skull to the brain. However, mouth guard use has not been conclusively proven to reduce the incidence of concussion in contact sports. The most recent and comprehensive meta-analysis of five cohort studies showed a relative concussion risk of 1.25 (CI 0.90-1.74) without mouth guard use compared to with use.¹² None of the studies were done on combat sports athletes, the studies varied on the type of mouth guard used, and compliance was noted to be unreported in half of the studies. Further research is needed to determine if mouth guards have a significant effect on preventing sport concussion, and whether the type of mouth guard used is important in this regard.

Theoretically a properly fitted athletic mouth guard may reduce the severity of concussions by the following mechanisms:

1. Direct dissipation and/or absorption of force of an upward blow to the jaw. Forces from mandibular impact would be attenuated with a mouth guard, resulting in fewer injuries. It has been shown that mouth protectors reduced pressure changes and bone deformation within the skull in a cadaver model. The amplitude of the intracranial pressure after a blow to the chin when wearing a mouth guard may be decreased by 50%.^{14,15,16}
2. Increased separation of the head of the condyle and glenoid fossa. When a properly fitted and balanced custom mouth guard is in place there is a forward/downward movement of the jaw, thus opening the space between the glenoid fossa and the condylar head. This may reduce the opportunity for the condylar head to directly impact the glenoid fossa after an upward blow to the jaw, thus reducing the impact and acceleration forces to the entire temporal region.
3. Increased head stabilization by activating and strengthening neck muscles. Activation of head and neck muscles at the time of impact will decrease the rotational forces on the skull, leading to less harmful movement of the brain inside the skull. Research has

suggested that being able to clench down on a mouth guard may activate muscles of the head and neck thus stabilizing the head.¹⁶ Some have suggested that this effect might be in place whether or not the athlete sees the impact coming.

Effect of Mouth Guards on Athlete Perception and Athletic Performance

Regarding the comfort of mouth guards, the most common complaints with mouth guard use are breathing issues, difficulty speaking, bad breath, dry mouth, nausea, or high cost.^{6,8} These complaints, along with lack of knowledge about use of this safety device, can affect the appropriate use of mouth guards and cause athletes to either forgo use altogether, or attempt to modify their mouth guards to allow for more comfortable wear.^{5,8} The complaints regarding comfort with mouth guard use seem to be better ameliorated with the use of custom mouth guards (type III) compared to the over the counter versions (type I and II).⁶

A systematic review evaluating the effect of mouth guards on athletic performance in amateur, elite, and professional athletes showed that custom made mouth guards did not interfere or improve performance when compared to control (no mouth guard) in a preponderance of studies.¹¹ This review showed that boil-and-bite mouth guards were found to adversely affect athletic performance compared to control in four studies, with two studies describing no effect on performance and two describing enhanced performance. This same review showed that custom mouth guards showed a smaller effect on specific physiologic parameters of athletic performance (forced expiratory air volume at one second, peak expiratory flow rates, forced vital capacity, and counter-movement jump) when compared to boil and bite mouth guards.

Discussion of Guidelines

Properly diagnosed, designed, and custom form-fitted mouth guards are essential in the prevention of athletic oral-facial injuries. The National Youth Sports Foundation for the Prevention of Athletic

Injuries, Inc. reports that dental injuries are the most common type of oral-facial injury sustained during participation in sports.¹⁷ It is estimated by the American Dental Association that mouth guards prevent approximately 200,000 injuries each year in high school and collegiate football alone.⁷

Though boil-and-bite mouth guards are the most used type in sports (largely due to lower cost and wide availability), the Association of Ringside Physicians does not recommend their use in combat sports. Available in limited sizes, these mouth guards often lack proper extensions and often do not cover all the posterior teeth. Athletes also cut and alter these bulky and ill-fitting mouth guards due to their poor fit, poor retention, and gagging effects. This in turn further reduces the protective properties of these mouth guards. When the athlete cuts the posterior borders or bites through the mouth guard during forming, the athlete increases their chance of injury. It may also lead to poor compliance during a bout, as some athletes dislodge the poorly fitting mouth guard anteriorly to reduce its effect on airway and soft tissue.

However, there are some basic design elements that can and should be included in any mouth guard that might enhance the protective effects of mouth guards. All mouth guards should have an adequate thickness and should cover as much of the occlusal surface as the athlete can tolerate. Mouth guards must have proper retention built into them to ensure that they stay in place at the moment of impact. Mouth guards should not be over-trimmed in the posterior horns because this might actually force the condyles into the glenoid fossae. All mouth guards should be balanced occlusally to ensure an even distribution of force across the entire surface.

Some athletes may have developed habits that increase the risk of orofacial injury, one common example being opening the mouth during punching. Many martial artists are taught to use the *kiai* or *kihap* during their training and competition. This short yell is purported to focus their energy on the strike and tighten up the core musculature.

However, athletes who open the mouth during the kiai can lose some of the stabilizing protection of the mouth guard and be more likely to have the mouth guard dislodged or knocked out of their mouth. While these habits are often difficult to break, athletes and their coaches should be educated by ringside physicians on the benefits of a clenched jaw kiai.

Regulating commissions, referees, and officials also play an important role in injury prevention and mitigation during combat sports. While all state commissions currently require mouth guards for regulated combat sports, they should consider additional rules requiring custom-made mouth guards, which have been proven to prevent injury better than boil-and-bite or ready-made mouth guards. Referees should ensure that athletes always have their mouth guards in during a bout (other than between rounds) and consider disqualification of athletes whose mouth guards are repeatedly dislodged or knocked out.

The Association of Ringside Physicians recommends that custom-made, form-fitted mouth guards (especially those of the laboratory lamination type) be constructed for each athlete by a dentist and evaluated annually. This should afford the athlete the very best in oral-facial protection as well as possible concussion deterrence.

Qualifying Statement

These guidelines are recommendations to assist ringside physicians, combat sports athletes, trainers, promoters, sanctioning bodies, governmental bodies, and others in making decisions and setting policy. These recommendations may be adopted, modified, or rejected according to clinical needs and constraints and are not intended to replace local commission laws, regulations, or policies already in place. In addition, the guidelines developed by the ARP are not intended as standards or absolute requirements, and their use cannot guarantee any specific outcome. Guidelines are subject to revision as warranted by the evolution of medical knowledge, technology, and practice. They provide the basic recommendations that are supported by synthesis and analysis of the current literature, expert and practitioner opinion, commentary, and clinical feasibility.

Acknowledgments

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CELEBRITY BOXING, AGED FIGHTERS: MEDICAL RAMIFICATIONS

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DISCLOSURES: The author serves NKS serves as Associate Editor, *The Eastern Journal of Medicine*, and Chief Medical Officer (CMO) of the New York State Athletic Commission (NYSAC). The views expressed by the author are his own and do not necessarily reflect the views of the institutions and organizations which the author serves.

Professional boxing is a combat sport which carries high risk for both acute and chronic neurological injuries. Traumatic subdural hematoma (SDH) remains the most common cause of boxing-related mortality.^{1,2,3,4} A typical professional boxer is a healthy young athlete in the age range of 20 to 35 years. Apart from excellent physical conditioning, these young athletes are typically free of common cardiovascular and cerebrovascular disease comorbidities such as essential hypertension, diabetes mellitus, dyslipidemia, coronary artery disease, and carotid artery disease. The recent past has seen several highly publicized, high-profile fights between aged fighters. Typically, the combatants are famous retired boxers with checkered professional pugilistic careers who come out of retirement to have one “last” fight against each other. These fights are typically marketed as exhibition fights. They occur under the jurisdiction of a boxing commission and may have special rules and accommodations in place such as fewer number of rounds with no judges at ringside. Another trend which has gained popularity are so-called celebrity boxing matches where in two social media personalities (such as YouTube or TikTok) with millions

of online followers either fight each other or a social media celebrity fights an aged, now retired, professional boxer. Frequently in these cases the celebrity fighter or fighters have little to no professional boxing background or experience. Yet they are allowed to enter a ring and trade punches (often wild) with either each other or a more skilled, but now aged, professional boxer. That there is a market for such fights is evident by the number of pay-per-view (PPV) buys generated. It is evident that at least a fair number of boxing fans are keen to witness such contests. As a result, it is expected such contests are going to become more commonplace soon. This begs the question of the medical implications of letting older and celebrity fighters fight. What are the risks to the health of these aged “retired” athletes or the younger unskilled celebrity fighter(s) and how can these be mitigated?

As we dwell into this further, it is wise to remind ourselves that boxing is a combat sport. While it can be made safer, it is impossible to make it completely safe. Boxing is also unique among other combat and contact sports such as mixed martial arts (MMA) and American football in that every

punch thrown at the head is thrown with the intention to win by a knockout (KO); that is, winning by causing a concussive injury to your opponent. Many of the fans of the sport and a healthy number of these celebrity fighters do not realize that you do not need a dramatic KO for a concussive injury to take place. Subconcussive injuries occur commonly during the midst of a boxing bout. Every time a fighter walks into a stiff jab or a straight right and “sees the stars”, “has his bell rung”, has a glazed glassy look, or feels his legs wobble under him he has likely suffered a mild concussion. The initial symptoms of a concussion are entirely subjective and include headache, sensation of pressure in the head, subjective feeling of dizziness, light (photophobia) and sound (phonophobia) sensitivity, nausea, feeling foggy or fuzzy in the brain. As a result, many fighters do not realize themselves that they are concussed and continue to fight. In other contact sports such as American football, an athlete can be pulled out of the game on account of a subconcussive injury. The game continues despite his absence and fans get their money’s worth. Boxing on the other hand does not allow the ringside physician this luxury. It is unique in the sense that if every fight is stopped by the referee or the ringside physician on account of subconcussive injuries, there would be no boxing at all, at least not in its current form.

It does not need a neurologist to opine that as the brain ages its ability to withstand trauma declines. Getting dinged when you are 20 is not the same as getting dinged when you are 50 or above. An older brain gets concussed more easily and older people voice more post-concussive symptoms as compared to the young. It is a well-known fact that subdural hematoma become more common as one ages. Sometimes seemingly minor head trauma such as bumping the head against a door can lead to a subdural in the elderly; and, as stated before, SDH is the most common cause of boxing-related mortality. Fights between two aged fighters or between two inexperienced YouTubers or between an inexperienced YouTuber and an older retired boxer merit close medical supervision and oversight right from the time the fight is proposed

(comes on the card). In my professional opinion, all such fighters need a good quality MRI brain scan including susceptibility weighted imaging and gradient echo imaging sequences, which are more sensitive in detecting microbleeds and stigmata of prior traumatic brain injury. In the case of the older retired professional fighters returning to the ring, the scan should be compared with their last MRI on file when they were actively boxing. Neuroimaging can help in determining brain fitness to fight. Presence of cerebral volume loss, cerebral or cerebellar atrophy, dilated ventricles, microbleeds in the new scan as compared to the prior should all raise a red flag. An older fighter should also undergo a formal neurocognitive evaluation as part of the prefight medicals. This testing, ideally done by a neuropsychologist, takes a few hours but is extremely sensitive in qualifying and quantifying the fighter’s IQ, clinical reaction time, attention, concentration, memory (short-term/long-term/verbal/auditory), executive functioning, as well gives insight into his mental health. If available, the results should again be compared with prior neurocognitive assessments. Any decline in cognitive and executive functioning, mood, and behavioral changes should trigger a red flag. The fighter should then be examined by a neurologist looking carefully for extrapyramidal signs such as tremor in the hands, stiffness, rigidity, mask like facies, shuffling gait, and slurred speech. If Parkinsonian signs are detected, no matter how subtle, the fighter should not be allowed to fight. Older retired fighters and inexperienced celebrity fighters also need a detailed cardiovascular examination prior to medical clearance to fight. An electrocardiogram (EKG), echocardiogram (ECHO), cardiac stress test and evaluation by a cardiologist is indicated in most cases.

While these fights are labeled as exhibition fights, they generate a fair amount of hype in the media. Preceding the fight, the two combatants build up the fight and it is not uncommon to hear them solemnly promising to knock the other out or make sure that he is “carried out on a backboard”. While a lot of this is bravado, these fights still warrant close medical supervision ringside. If concern

for concussion is raised, the referee or the ringside physician should have a low threshold for stopping the contest. The ringside physician should remember that while a “young” brain may bounce back from a concussion, an “old” brain may never recover from a serious beating or a flurry of punches. A fighter can always live to fight again but if a serious traumatic brain injury were to occur these aged fighters are not coming back again. An older fighter demonstrating signs of early Parkinson’s disease may decline rapidly after a brutal beating in the ring.

Celebrity boxing fights between older retired boxers or between a social media personality and an older boxer are here to stay. A fair number of boxing fans want to see these fights. As we strive to make these fights happen, let us not let our medical and Commission regulatory standards slide. We in fact need to step up our medical- and Commission-level supervision of these contests. If we do not do this, we risk losing all the hard work we have done collectively as doctors, referees, regulatory Commission officials, members of boxing governing bodies, and promoters to make boxing safer.

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TOO OLD TO BOX: SHOULD THERE BE A MANDATORY RETIREMENT AGE IN BOXING?

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Boxing is a popular combat sport. Top professional boxers rank consistently among the highest paid athletes in the world and the bright lights of the boxing ring lure young men and women to join its rank seeking fame and money. A demanding physical sport, boxing requires many athletic skills apart from excellent cardiovascular conditioning such as punching power, foot work, hand-eye coordination, flexibility, and manual and mental dexterity. Most boxers who turn “pro” in their early 20s have a career spanning 10 to 15 years (till their mid-30s). Recently more and more professional boxers are boxing into later years driven predominantly by economic factors to provide for themselves and their families. There has been a tandem rise in boxers in their mid to late 40s and some in their early 50s coming out of retirement to compete again in bouts marketed as exhibition matches. When these aging boxers enter the ring, they are potentially placing their health at risk. Safeguards to protect these aging boxers will allow some of them to box safely enriching the sport and enthraling fans with their skills and “boxing” wisdom borne of experience.

At present there is no age-based mandatory retirement in boxing. Some commissions, however,

classify a boxer who is 40 years and older as a high-risk combatant. Heightened medical screening of these combatants is demanded to assess cardiovascular and neurological fitness to fight. This may include magnetic resonance imaging (MRI) of the brain with susceptibility weighted imaging (SWI) or gradient echo imaging (GRE); magnetic resonance angiogram (MRA) of the brain to detect vascular malformations such as aneurysms and arteriovenous malformations (AVM); neurological evaluation performed by a neurologist; formal neurocognitive testing either via a neuropsychologist (pen-and-paper testing) or computerized testing such as ImPACT test; cardiac evaluation performed by a cardiologist; and additional blood work including a complete blood count (CBC) with platelet count and complete metabolic panel (SMA20) which includes hepatic tests, blood urea nitrogen, creatinine, glucose, lipid profile, and thyroid profile.

The question follows: are older boxers more prone to the health risks associated with boxing, predominantly concussion and traumatic brain injury? The answer is an emphatic “yes”. There is an age-related decline in athletic skills such as hand speed, foot work, durability, hand-eye coordina-

tion, agility, and flexibility making the boxer more vulnerable to concussion, traumatic brain injury, and injuries in general, especially when matched against a younger opponent. As the brain ages its ability to withstand trauma declines. Getting dinged when you are 20 is not the same as getting dinged when you are 40 or above. An older brain gets concussed more easily and older people voice more post-concussive symptoms as compared to the young. Traumatic subdural hematoma (SDH) is the most common cause of boxing-related mortality, and it is a well-known fact that SDH become more common as one ages.^{1,2} Sometimes seemingly minor head trauma such as bumping the head against a door can lead to a subdural in the elderly.

Identification of a high-risk fighter based solely on age criterion, however, is neither error-free perfection nor scientific. Professional boxers are elite athletes who have benefitted from years of demanding physical training that can mask underlying physical vulnerabilities. There is considerable interindividual variability and even in one individual uneven decline occurs in various physical abilities and attributes. Repositories of skills may remain well-preserved while others decline.

Age-based mandatory retirement would be met with understandable boxer and promoter-led resistance. Regulatory authorities face competing demands to allow boxers to ply their trade while maintaining the safety of the combatants and full transparency in their decision-making process. Boxers facing mandatory retirement may feel unfairly treated and challenge results ensuring costly and time-consuming court actions.

Perhaps episodic and more detailed medical evaluations of boxers after a certain age (such as 40), when incidence of decline in physical attributes is known to increase, may be appropriate and should include neuroimaging studies, neurological, and cardiological evaluations. The focus of these evaluations should be an assessment of a boxer's physical conditioning, cardiovascular status, and detection of subtle signs of neurodegenerative diseases associated with multiple head trauma exposures, such as Parkinson's disease, Parkinsonism, chronic

traumatic encephalopathy, and dementia pugilistica. A two-stage process can be followed to ensure full transparency: an initial screening of the boxer followed by a more detailed, confidential evaluation if concerns are raised during the initial screening. Boxers who pass the evaluation should agree to a negotiated form of surveillance and repeat assessments after six months to one year should they choose to continue fighting. The goal of the medical evaluation should not be punitive, rather it should help identify vulnerable fighters who themselves may lack insight of their decline and exercise poor judgment by continuing to fight, protect them from further damage, and provide them with the resources needed to maintain and restore brain and heart health.

There are no easy answers. Facing a possible revocation of their license to fight, fighters may resist undergoing any medical testing. It is important to remember that a boxer fights not just for money and obligations to provide for his family. Self-esteem, glory, and fame are an equal, if not more important, impetus to fight. There are instances of boxers falling prey to depression, drugs, and alcohol after retirement. Hence, a cautious and sensitive approach is needed to support these aging fighters. Boxers who are no longer able to fight should have other meaningful options available such as working as trainers, coaches, cut men, and sports commentators.

The impetus for the above commentary is solely to develop self-regulatory guidelines designed to protect the health of the aging fighter.

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ESTABLISHING A NATIONAL MEDICAL DATABASE IN BOXING: A LONG OVERDUE NEED OF THE HOUR

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Boxing in the United States is regulated by individual state and tribal athletic commissions. When it comes to medical prerequisites for initial licensure to fight and maintenance of this certification, requirements vary from commission to commission. For example, when it comes to neuroimaging requirements for licensure to fight some commissions require a computed tomography (CT) scan while others require a magnetic resonance imaging (MRI) scan. The imaging specifics and frequency also vary widely across different commissions.

During his or her professional career, a boxer usually fights under different commission jurisdictions. As things stand today, when a fight comes on the card, the boxer's medicals are submitted to the attention of the supervising commission's medical team. These medical documents are usually submitted by either boxers' promoter or the boxers themselves. The submitted medical documents are reviewed by the commission's medical team to determine medical clearance to fight. If any concern is raised, further tests may be requested by the commission's physician(s). These documents are retained by the commission on file for future

reference. Since boxing currently lacks a national medical database, these medicals are not shared among various commissions under whose jurisdiction the boxer may fight in the future. A medical concern identified by one commission is not automatically communicated to another commission allowing the fighter to potentially be cleared to fight under that commission's jurisdiction. This risks the health of that fighter.

In the United States, adoption and maintenance of electronic medical records (EMR) is now federally mandated for all healthcare providers and other eligible professionals. EMR have many advantages over the traditional paper records. Besides been more secure and in compliance with the mandates included in the Health Insurance Portability and Accountability Act (HIPAA), one big advantage is portability and transmissibility across different healthcare providers.

Availability of EMR systems also makes the vision of a national medical database in boxing viable. However, several important details first need to be addressed by the concerned parties to make this vision a reality:

1. **What medical data will the boxer national medical database contain?** Results of all tests which are mandatory for initial licensure and maintenance of medical certification to fight should be available on the database. These include neuroimaging tests such as CT scan head and MRI brain, hepatitis B and C serology, HIV test, complete blood count including platelet count, prothrombin time (PT), international normalized ratio (INR), electrocardiogram (EKG), pregnancy test result for the female boxer, results of the dilated eye examination including visual acuity and urine test results including positive test results indicating the use of illicit substances and performance enhancing drugs (PED). For a high-risk fighter (usually a fighter above the age of 40), the database should contain the results of other tests such as magnetic resonance angiography (MRA) head, echocardiogram, and neurocognitive testing. A comprehensive national medical database should also contain information about the boxer's fight history including medical suspensions, list of medications and supplements, and therapeutic use exemptions (TUE) if any.
2. **How will this online electronic boxer national medical database be made secure?**¹ The privacy of the boxers and the security of their medical information is a fundamental concern and barrier to overcome if we wish to make this database a reality. Utilizing the services of an established EMR vendor with a proven track record of using advanced security techniques may be the best option to address these concerns.
3. **Who establishes and maintains this database?** Reasonable candidates for this task would either be the Association of Boxing Commissions (ABC) or a non-profit medical association such as the Association of Ringside Physicians (ARP). To establish and maintain this database would require funding which would come from the various state athletic

commissions and sport governing bodies. Boxers or the designated promoter would be required to submit/upload the medicals to the database rather than submit to the individual athletic commission's attention.

4. **Who would have access to this database?** In order to ensure that boxer's medical information is kept confidential and in accordance with HIPPA mandates, access to the database would be restricted to identified medical professional(s) of various state athletic commissions who would be able to log on and access the information with the aid of user-specific name and password.

A national medical database would not only streamline the process of review of medicals prior to a fight, it shall also go a long way in protecting health and enhancing safety of boxers, making the sport safer and better medically supervised by standardizing medical requirements across various commissions. A boxer's medical history would be readily available at the click of a mouse making it easier to identify the high-risk fighter who needs additional testing or closer medical supervision. For an individual boxer, review of neuroimaging studies carried out over the boxer's fighting career will make it feasible to identify subtle signs of traumatic brain injury and neurodegeneration. Such boxers can then be red flagged and a decision to allow them to fight can be made by the individual state athletic commission's medical team on a case-by-case basis. The database can be expanded to include all post-fight medicals such as those of a fighter sent to the emergency department after a boxing bout for an emergent CT scan of the head to rule out acute traumatic brain injury or an X-ray of the hand to rule out a fracture. For the boxer returning to the ring after sustaining a concussion or a broken hand in a previous fight, the database would prove valuable in risk stratification and prognostication. The database would also help to reduce unnecessary, repetitive and costly tests such as CT scans, also reducing the radiation exposure which the fighter incurs during

these tests. The medical database will also serve as an invaluable resource for researchers studying the effects of multiple concussions and implementing interventions designed to mitigate the harmful effects of boxing on the brain.

A national boxing medical database is the need of the hour. Let us join hands to make this happen.

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STANDARDIZED POST-FIGHT MEDICAL EVALUATION PROTOCOL FOR BOXERS

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Background

Professional boxing is a popular combat sport with a high risk for various injuries including but not restricted to acute traumatic brain injuries (TBIs) (such as concussion, subdural hematoma, subarachnoid hemorrhage, intracerebral hemorrhage, dissection of great vessels of the neck), orthopedic injuries (such as fractures of the hand, boxer's knuckles, shoulder dislocation, ligamentous injuries to the knee joints and ankle), ophthalmological injuries (such as fractures of the orbit with entrapment of extraocular muscles, eyelid lacerations, corneal abrasions, retinal detachment), dental injuries (such as traumatic avulsion of a tooth), oromandibular injuries (such as fracture/dislocation of the jaw), traumatic tympanic membrane perforation, lacerations of the face, lips, eyelids

and infrequent but serious injuries such as laceration of the liver or spleen. Failure to recognize the above-mentioned injuries at the time of the post-fight medical evaluation can result in delay in diagnosis and management leading to disability and death in some instances.

Discussion

Professional boxing is a popular combat sport in which neurological, orthopedic, dental, and ophthalmological injuries are common. Professional boxing currently lacks standardized post-fight medical evaluation protocol. Ringside physicians come from various disciplines of medicine such as neurology, orthopedics, internal medicine, family medicine, and sports medicine with varying proficiency and experience in identification and man-

agement of the myriad of injuries which may be encountered in boxing. In the absence of a standardized post-fight medical evaluation protocol, injuries may be missed, or the clinical significance of an injury may not be realized, risking the health and safety of a boxer.

Conclusion

Developing and implementing a standardized post-fight medical evaluation protocol would help standardize medical decision-making processes and help protect combat sports athletes' health. Here a standardized post-fight medical evaluation protocol is proposed with the recommendation that the proposed protocol be debated vigorously by the ringside physician community and evidence-based guidelines be developed by the medical community in conjunction with professional boxing governing bodies.

Keywords: Boxing, Safety Injuries

Professional boxing is a popular combat sport with high risk for injuries involving the brain, joints of the upper and lower limbs, face, jaw, and teeth. While many of the injuries are not life threatening, they can lead to significant disability if not identified in a timely fashion and managed appropriately. Acute TBIs, namely subdural hematoma; acute epidural hematoma; subarachnoid hemorrhage; intracranial hemorrhage; and second-impact syndrome (SIS), are life threatening, leading in some cases to death of the boxer in the ring or soon after the completion of the bout.

In professional boxing bouts, all boxers undergo a pre-fight and post-fight medical evaluation. This evaluation is conducted by a ringside physician. Ringside physicians come from various disciplines of medicine such as neurology, orthopedics, family

medicine, internal medicine, and sports medicine, and have varying degrees of ringside experience with some supervising only a few fights each year. A ringside physician from an orthopedic background while highly competent in the identification and management of orthopedic injuries may lack proficiency and experience in identification and management of a common boxing injury like concussion. Many of these non-neurologist physicians are neither comfortable nor proficient in conducting a neurological examination. Similarly, a neurologist may neither be proficient nor comfortable with management of an acute orthopedic emergency such as a knee dislocation or compartment syndrome. Ringside physicians are entrusted with the health and safety of the boxers. Their job is made more difficult since important medical decisions must be made quickly based solely on the history elicited from the injured fighter and clinical examination. At the fight arena, a ringside physician does not have the luxury to order imaging studies, diagnostic tests, and the decision to transport the boxer to the emergency department of the nearest trauma center or to discharge him home is made solely on clinical grounds.

Developing and implementing a standardized post-fight medical evaluation protocol would help ensure timely identification and management of the myriad of injuries involving different organ systems which are encountered in boxing, standardize medical decision-making processes, and help protect boxers' health.

The following standardized post-fight medical evaluation protocol is proposed based on personal and collective evidence of experienced ringside physicians and clinical acumen.

Standardized Post-Fight Medical Evaluation Protocol

1. The post-fight medical evaluation should ideally occur in a clearly demarcated dedicated room. In smaller arenas where this is not feasible, a makeshift medical tent (pop-up medical tent) may be erected by the arena staff for this purpose. The room/tent should be spacious, well-lit, and have a table and two chairs.
2. Post-fight all boxers should be evaluated in the medical room/tent. The practice of post-fight examination of the boxers in the ring itself (or ringside) and medical clearance for discharge should be strictly discouraged. After the fight is over, both of the boxers should be walked back to the post-fight medical evaluation room/tent by the assigned inspectors and ringside physicians. No boxer should be allowed to leave the ring unaccompanied.
3. Post-fight medical evaluation takes place after the bout. The boxer is walked to the post-fight medical evaluation room/tent by the assigned inspector and ringside physician who are the only people allowed in this area.
4. The gloves are usually removed in the ring itself and the hand wraps should be cut in the medical evaluation room.
5. Post-fight medical evaluation begins with history. The boxer is asked how he feels and if he has suffered any injuries. Open ended questions can include:
 - How are you?
 - How do you feel?
 - Does anything bother you?
 - Are you hurt?

If the boxer volunteers an injury, more direct questions pertinent to that organ system should follow. Since acute TBIs are the most dreaded of boxing injuries, every boxer should be asked about presence of neurological symptoms such as headache, nausea, dizziness, light sensitivity, sound sensitivity, vision problems (blurred vision, diplopia), any weakness in the arms or legs, incoordination, problems with balance and gait.
6. Post-fight vitals (heart rate, blood pressure, respiratory rate) should be obtained, though are of limited clinical significance in the awake, alert boxer.
7. The techniques of physical assessment remain the same and begin with an inspection of the boxer from head downwards. This is a good time to look for lacerations. The tympanic membranes should be assessed by a handheld battery-operated otoscope to rule out traumatic perforations, especially if blood is noted in the external ear canal. A close inspection of the small joints of the hands, wrists, elbows, and shoulders follows. If any obvious swelling, deformity, or crepitus is identified, closer inspection of that joint follows. Gentle manipulation of the joint may be performed. Pain, inability to bear weight, difficult moving the joint, swelling, obvious deformity, bruising, and tenderness all raise concern for fracture.
8. Any boxer who suffered a knock-out (KO) or knock-down during the fight should be assessed for concussion. Concern for concussion and TBI is also raised if the boxer is confused post-fight or is unable to respond appropriately to questions. Assess for anterograde and retrograde amnesia with the use of Maddocks questions such as: What venue are we at today? Which city are you in? Who is your coach? Who did you fight today? How many rounds did you fight? Who did you fight last? Concern for concussion/TBI is raised if the boxer is unable to answer or answers wrong to the above questions and voices any new and/or persistent symptoms such as headache, nausea, dizziness, blurring of vision, or double vision.
9. Neurological assessment and examination: every boxer should have a neurological examination post-fight.

The ringside physician should assess for the presence or absence of concussion/traumatic brain injury with the aid of a multimodal concussion/TBI assessment battery including the following:

a) Glasgow Coma Scale (GCS) Score (best motor response, best verbal response, and eye-opening). A CGS score less than 13 is mandatory transfer to the ER of the designated Level I Trauma Center via on-site ambulance for urgent CT scan of the head to rule out acute TBI.

b) Neurological examination including cranial nerve testing (look for pupil symmetry and extraocular movements, pronator drift testing, finger-to-nose testing, Romberg's test and tandem gait). Any focality in neurological examination is mandatory transfer to the ER of the designated Level I Trauma Center via on-site ambulance for urgent CT scan of the head to rule out acute TBI. Focal neurological examination signs may include:

1) Asymmetry in pupil size (afferent cranial nerve II, efferent cranial nerve III).

2) New onset ptosis (drooping of one eyelid) (cranial nerve III). Differentiate from pseudo-ptosis where one eyelid appears to droop due to eyelid swelling.

3) New onset diplopia/double vision (test for binocular Vs, monocular diplopia) (cranial nerves III, IV, and VI). Diplopia due to central/brain causes is present in binocular vision (when both eyes are open and resolves when one eye is closed irrespective of which eye is closed). Diplopia in monocular vision is usually on account of local traumatic pathology in that eye itself.

4) New onset facial asymmetry (cranial nerve VII).

5) Pronator drift—one arm drifts down and pronates when the fighter has both arms extended in front of him, palms facing upwards and has his eyes closed. Presence of a pronator drift indicates a subtle weakness in the arm which pronates (corticospinal tract sign).

6) Finger-nose test—this is an appendicular cerebellar sign. If the fighter is “off” on finger-nose testing on one side, concern is raised for an appendicular cerebellar lesion/bleed on that side.

7) Romberg's sign—the fighter stands with his feet together and is asked to close his eyes. If he starts to sway and cannot maintain balance that is a positive Romberg's sign and indicates dysfunction of the posterior columns.

8) Gait assessment including tandem walking—assesses the midline vermal function of the cerebellum. If the fighter is unable to tandem walk, that may indicate an intracranial lesion.

c) Standardized Assessment of Concussion test (SAC)—check orientation, immediate memory, concentration, delayed recall.¹

d) Balance Error Scoring System (BESS) test—double-leg stance, single-leg stance and tandem-leg stance.²

e) King-Devick test measures the speed of rapid number naming (reading aloud single-digit numbers from three test cards), and captures impairment of eye movements, attention, language, and other correlates of suboptimal brain function.³

The ringside physician should assess for any signs of gross motor instability and ataxia such as incoordination, stumbling, inability to walk in a straight line, and inability to maintain stance with eyes open and closed.

10. Every post-fight medical evaluation should include palpation of the ribcage to rule out rib fractures, palpation of the abdomen, especially if the boxer voices abdominal tenderness and basic auscultation of the heart and lungs.

As good practice guidelines, the following are further suggested:

1. The ringside physician should document all the pertinent findings on the post-fight medical evaluation form.
2. If the decision is made to transport the boxer to the emergency department, the reason for transfer and the tests requested should be clearly documented along with the boxer's condition at the time of transfer/hand-off to the EMS personnel.
3. If a boxer is given a medical suspension this should be documented along with the cause and duration of suspension. If the boxer needs medical or specialist clearance prior to return to boxing, this too should be documented. This ensures that an injured boxer does not return to competitive boxing prematurely.
4. Before discharge from the venue, the boxer and his camp should be educated about the signs and symptoms of concussion, TBI, and other relevant injuries, and advised to go to the nearest emergency department if any of these symptoms are encountered post-discharge.

Conclusion

It is recommended that the above proposed standardized post-fight medical evaluation protocol be debated vigorously by the ringside physician community and be further refined by the medical community in conjunction with professional combat sports governing bodies. Boxing can be made safer and having a standardized post-fight medical evaluation protocol is needed.

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STANDARDIZED POST-CONCUSSION RETURN TO BOXING PROTOCOL

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Background

Concussion is a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces. Immediately following a concussion, an athlete is usually advised physical and cognitive rest till post-concussion symptoms abate. The athlete then enters a stepwise return to play protocol. Premature return to play risks a second concussion, second impact syndrome, exacerbation and persistence of post-concussive symptoms. Various sports governing organizations such as the National Football League have developed post-concussion return to play protocols to enhance athlete safety.

Discussion

Professional boxing is a popular contact sport in which concussions are common. Boxing is a combat sport and is unique in that every punch

thrown at the opponent's head is thrown with the intention of winning by a knockout (KO), in other words, by causing a concussion. Currently professional boxers are arbitrarily suspended for periods ranging from 30 to 90 days after suffering a technical knock-out (TKO) (typical medical suspension ranges from 30-45 days) due to multiple head shots or after a knockout (KO) (typical medical suspension is 90 days). This period of medical suspension, however, is not uniform across different boxing commissions. In the absence of a standardized post-concussion return to boxing protocol, boxers frequently begin to spar and train for their next fight soon after their TKO/KO, endangering their neurological health and safety. Boxing commissions also differ with respect to their return to boxing requirement after a TKO/KO. While some commissions such as New York require a neurology clearance for the medical suspension to be lifted, others allow an automatic return to ring after the suspension period is over.

Conclusion

Developing and implementing standardized post-concussion return to boxing protocol shall standardize return to boxing decision-making process and help protect boxers' brain health. Here a post-concussion return to boxing protocol is proposed with the recommendation that the proposed protocol be debated vigorously by the scientific community and evidence-based guidelines be developed by the medical community in conjunction with professional boxing governing bodies.

Keywords: Boxing, safety, concussion, return-to-play

Concussion can be defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.¹ Concussion typically involves temporary impairment of neurological function with full recovery expected over a course of time. Currently there are no sensitive or specific biofluid (blood or cerebrospinal fluid) or imaging markers to identify and grade a concussion injury. In the absence of a valid and reliable biomarker of concussion, current emphasis is on early and accurate identification of the concussion, pulling the player out and advising cognitive and physical rest till symptoms abate. Sports such as American football now have a standardized return to play protocol. After a period of cognitive and physical rest, a graded and gradual return begins under the watchful eyes of the athletic trainer(s). The athlete is closely supervised as he progresses through the return to play protocol. If he reports re-emergence of post-concussion symptoms or exacerbation of post-concussion symptoms on exertion, he is not allowed to proceed further till the symptoms abate. Once the player is asymptomatic even after full contact exercise session, a final clearance to return to play is requested from an independent neurotrauma consultant (INC). The INC is a neurologist or neurosurgeon with expertise in concussion recognition and management who is not affiliated to the team and thus free of any bias.

Boxing is a unique combat sport in that every punch thrown at the head is thrown with the inten-

tion of causing a knockout (KO). No single definition of concussion shall be universally accepted in boxing and identifying mild grades of concussion (subconcussive blows) during the course of a boxing fight is thus particularly challenging. It would not be unreasonable to say that a boxer suffers many concussive and subconcussive injuries during the course of a bout. Thus, boxing requires close medical supervision and standardized protocols to identify and manage concussive injuries.

To help identify and manage concussive injuries in boxing, the following recommendations are proposed based on evidence from other sports and the author's clinical acumen and ringside experience:

1. A knockdown caused by punch to the head should raise concern for a concussion even if the boxer gets back to his feet before the 10 count.
2. If a boxer is knocked down by a punch to the head and is unable to get up within the 10 count (knockout), he should be automatically deemed to have suffered a concussion and treated as such.
3. A boxer who suffers a technical knockout (TKO) on account of multiple head shots, should be closely assessed for concussion at the ringside and in the locker room.
4. A boxer who suffers multiple head shots during the course of the bout should be watched closely during the fight and assessed for concussion in-between the rounds and after the fight is over.
5. A boxer who is determined to have suffered a concussion during the course of a fight should not be allowed to continue to box if he is symptomatic. Symptoms of concussion are varied and include complaint of headache, nausea, double or blurred vision, disorientation and confusion, post-traumatic amnesia, amnesia for events surrounding the fight (e.g., the name of the venue, name of the opponent, round in which KO or TKO occurred), and impaired coordination, balance or gait.² The fight should be stopped by the referee or the ringside physician on medical grounds. Such a boxer should be assessed at the ringside or

in the locker room for concussion with the aid of standardized tests such as Standardized Assessment of Concussion (SAC) test, Balance Error Scoring System (BESS), and King-Devick test.^{2,3,4,5} Such multimodal assessment for concussion improves diagnostic accuracy.

6. A boxer who is determined to have suffered a concussion should be closely watched in the locker room for any signs of neurological deterioration. Any boxer with a Glasgow Coma Scale (GCS) less than 15 should not be discharged from the event venue till he returns to baseline. The decision to transport the boxer to the nearest Level I trauma center for evaluation (diagnostic imaging to rule out intracranial hemorrhage) and management should be made on a case-by-case basis.
7. Mandatory 90-day medical suspension should be issued at the venue for a KO caused by a head blow. This boxer then enters the post-concussion return to boxing protocol. For a TKO caused by head and body blows, period of suspension ranges from 30 (body shots) to 45 (head shots) days. If the boxer, after evaluation by the ringside physician, is deemed to have suffered a concussion, the period of suspension should be extended to at least 90 days and the boxer enters the post-concussion return to boxing protocol.
8. A boxer who is determined to have suffered a concussion should be debarred from sparring or boxing until he is symptomatically back to baseline.
9. The boxer is instructed to see a physician within 24 hours of sustaining a concussion. The physician may be a commission-appointed physician or an independent, unaffiliated physician, preferably a neurologist licensed in the state/country of residence of the boxer.
10. As in American football, after a few days of cognitive and physical rest, a graded and gradual return to the sport should begin under the watchful eye of the coach.

Post-concussion return-to-boxing protocol

Once the boxer is symptom free for at least 24 hours and a medical release to return to the gym has been signed by the treating physician, he/she can begin a graded return to boxing as detailed below.

1. Begin with light aerobic activity (walking or stationary bike for 10 minutes, no resistance training).
2. If asymptomatic, progress to boxing-specific activities such as jumping rope and shadow boxing.
3. If asymptomatic, progress to non-contact training skill drills (e.g., pad work, speed bag, heavy bag, etc.).
4. If asymptomatic, progress to light sparring with full head gear.

There is no fixed time limit on each of the above steps. If any post-concussion symptoms occur while in the stepwise return to boxing program, then the boxer should be instructed to drop back to the previous asymptomatic level and try to progress again after a further 24–48-hour period of rest has passed.

1. Return to competitive boxing only occurs when the period of mandatory medical suspension (90 days for a concussion) has expired. There should be no exceptions to this rule.
2. Before return to competitive boxing every boxer should undergo a final neurology clearance to fight by an independent, unaffiliated neurologist.

As good practice guidelines, the following are further suggested:

1. The referee, ringside physicians and boxing coaches should be skilled in identifying concussions in the ring and in the management of a concussed boxer both in the ring and gym.
2. Establishing a database which tracks the number of concussions sustained by a professional boxer. This goal of the database shall be to

accurately record, and report concussions sustained by an individual boxer. This shall help in prognosticating the boxer when to hang up his/her gloves as well as a valuable tool for research on concussion risks, treatment, and management.

3. Every professional boxer should have a formal neuropsychological (neurocognitive) evaluation at the time of starting his professional career, at the midway point and towards the end of his career. A decline in neurocognitive function should raise concern and be further assessed on a case-by-case basis.
4. Emphasis should be placed on educating boxers, trainers, and coaches about concussions and the reported link between multiple concussions and chronic traumatic encephalopathy (CTE).

Conclusion

It is recommended that the above-proposed protocol be debated vigorously by the scientific community and evidence-based guidelines be developed by the medical community in conjunction with professional boxing governing bodies. Boxing can be made safer and a standardized return to boxing protocol is needed.

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TRAUMATIC TYMPANIC MEMBRANE PERFORATION IN BOXING: A CASE SERIES

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KEYWORDS: tympanic membrane, ear drum, perforation; rupture; combat sports; boxing

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DATA SHARING STATEMENT: the author has no additional data to share.

Abstract

Professional boxing is a popular combat sport carrying a high risk for acute and chronic traumatic brain injuries (TBIs) as well as injuries to the hands, shoulders, and eyes. Traumatic tympanic membrane perforation (TTMP) has not been well documented in the boxing medical literature as compared to neurological and orthopedic injuries commonly associated with the sport. In this case series, five boxers with TTMP are described. The mechanism of injury, clinical presentation, management, and prognosis is discussed.

Case report

Five boxers with TTMP were identified during the course of professional boxing bouts from the period 2018-2020. The boxers varied in age from 20 to 35 years and from welterweight (147 lbs.) to heavyweight (200 lbs. and above) weight class. All the five boxers were men and the injury occurred

during the bout (4-round to 10-round bouts). Two of the five boxers made the ringside physician aware of their injury during the fight itself (one in the third round and the other in the fifth round). In one of these boxers, blood was seen oozing out of the left ear during the fight leading to the diagnosis of TTMP. The boxer did not complain of any symptoms and the fight was allowed to proceed after examination by a ringside physician. In the other three boxers, the injury was documented during the post-fight physical examination when the boxer complained of symptoms suggestive of TTMP though, retrospectively, all the five boxers were able to identify the round during which the injury occurred and sometimes even the causative punch. The boxers used the following phrases to draw attention to their injury: “I felt my ear pop”, “I feel air whooshing through my ear”, “my ear hurts”. In none of the five boxers was the fight stopped (by the boxer himself, his corner, referee, or the ringside physician) on account of the injury.

Post-fight, battery-operated otoscopic examination confirmed the diagnosis of TTMP in all five boxers. Blood was identified in the external ear canal in all five boxers. The type of perforation was central in two boxers and marginal in three. The sides affected were left ear in three boxers and right ear in two boxers. No boxer had bilateral TTMPs. Two boxers complained of decreased hearing in the affected ear, though this was not formally tested. Neurological examination was non-focal in four boxers. Nystagmus was not identified. Post-fight, one boxer was stable on his feet with eyes open but unable to maintain stance with eyes closed. His tandem gait was impaired.

All the five boxers were discharged home from the event venue itself with instructions to keep the affected ear dry. An average of 30 days mandatory medical suspension was given with instructions to follow up with an otolaryngologist after discharge.

Discussion

Traumatic tympanic membrane perforation is not a well-documented otolaryngological injury in professional boxing, though it is not uncommon in this combat sport. Examination with a handheld battery-operated otoscope usually documents the injury. The mechanism of injury is usually a direct blow (punch) to the ear. Sudden forceful air compression occurring from a punch delivered by an open or partially open glove can lead to TTMP.¹ The boxer may complain of acute pain, hearing loss, tinnitus, or vertigo immediately following the perforation. In most cases the injury does not prevent the boxer from continuing to fight. If frank blood is noted to be oozing out of the ear during the bout, it is prudent to call a timeout and examine the injured boxer to rule out a more serious etiology such as acute TBI with or without basilar fracture. Commonly the injury is documented during the post-fight physical examination when the boxer complains of pain in the ear, decreased hearing, tinnitus, or when blood is noted in the external ear canal.

In the author's experience TTMPs during boxing are not usually associated with dislocations of the ossicular chain, fracture of the stapedial footplate, displacement of the fragments of the ossicles, or a perilymph fistula from the oval or round window causing leakage of perilymph into the middle ear space.

Treatment is usually supportive as most TTMPs heal on their own. The boxer should be advised to keep the ear dry. Routine antibiotic ear drops are unnecessary. Prophylaxis with oral broad-spectrum antibiotic such as amoxicillin (500 mg every 8 hours for 7 days) and antibiotic ear drops are necessary if contaminants may have entered through the perforation as occurs in dirty penetrating injuries.² The boxer should be given a medical suspension and instructed to follow up with an otolaryngologist. Surgery is indicated for a perforation persisting greater than two months. Disruption of the ossicular chain may result in persistent conductive hearing loss necessitating surgical exploration and repair.

Conclusion

Traumatic tympanic membrane perforation is a not so uncommon otolaryngological injury in boxing. Early identification and proper management ensure a good outcome in most fighters.

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SHOULD A BOXER WITH INCIDENTALY DETECTED ARACHNOID CYST BE ALLOWED TO COMPETE?

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KEYWORDS: boxing, arachnoid cyst, intracystic hemorrhage, subdural hematoma, subdural hygroma

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AUTHOR CONTRIBUTIONS: NKS conceived, drafted and revised the manuscript.

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DATA SHARING STATEMENT: the author has no additional data to share.

Background

Professional boxing is a popular combat sport with a high risk for acute traumatic brain injuries (TBIs) such as concussion, subdural hematoma (SDH), epidural hematoma (EDH), subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH) and dissection of great vessels of the neck. It is unique among sports in that every punch thrown at the head is thrown with the idea of winning by causing a knockout (KO), a moderate grade of concussion injury of the brain. Most boxing commissions in the United States require neuroimaging either computed tomography (CT) or magnetic resonance imaging (MRI) of the brain as part of the medical requirements at the time of the initial licensure and periodically thereafter to determine brain fitness to fight. At times, arachnoid cysts are found as incidental findings in brain scans carried out in young healthy asymptomatic athletes and

the ringside physician has to determine to allow these boxers to fight or not.

Discussion

Professional boxing is a popular combat sport in which acute neurological TBIs are not uncommon. At times these injuries can be fatal. Arachnoid cysts are identified incidentally in brain scans done at the time of initial licensure. In non-contact sports, these cysts have little clinical significance and are not a contraindication to participation. However, in a combat sport like professional boxing where a fighter endures multiple hits to the head (head impact exposures), the significance of these cysts has to be carefully weighed by the ringside physician. Concern is raised that if a boxer was to bleed into a large arachnoid cyst (intracystic hemorrhage), or suffer a cyst associated subdural hygroma or SDH it would lead to an adverse clinical outcome.

Conclusion

The clinical significance of incidentally detected arachnoid cysts in brain fitness screening CTs and MRIs done in professional boxers is unclear. Fighters with small arachnoid cysts can be cleared to compete under close medical supervision. Large arachnoid cysts warrant a more conservative approach and denial of licensure to fight.

Keywords: Boxing, arachnoid cysts, MRI brain, CT scan head

Professional boxing is a popular combat sport with high risk for injuries involving the brain. Acute TBIs, namely SDH, EDH, SAH, ICH, and second-impact syndrome (SIS), are life threatening, leading in some cases to death of the boxer in the ring or soon after the completion of the bout.

In professional boxing, most boxers undergo a neuroimaging study, either a CT head scan or MRI brain scan to determine brain fitness to fight at the time of the initial licensure. An arachnoid cyst is an incidental finding in some scans of healthy asymptomatic boxers. Whether boxers with arachnoid cysts should be medically cleared to compete is unclear. Few studies have looked at risk of sport participation with arachnoid cysts. Data with respect to combat sports such as boxing and mixed martial arts (MMA) are lacking. Developing and standardizing medical decision with respect to arachnoid cysts would help protect boxers' health.

The following medical decision-making process with respect to arachnoid cysts and combat sports is proposed based on personal ringside experience and review of existing medical literature on arachnoid cysts and risk of sport-related brain injury.

1. Boxers with large-sized arachnoid cysts should be denied licensure to fight as there is an increased risk of SDH, subdural hygroma in association with the arachnoid cyst. Concern is also raised that if a boxer were to suffer an intracystic hemorrhage leading to elevated intracranial pressure, it would lead to an adverse clinical outcome.

2. Boxers with posterior fossa arachnoid cysts need closer medical evaluation to determine brain fitness to fight. As a rule, ringside physicians should have a low threshold for denying medical licensure to these fighters. Boxers with very small posterior fossa arachnoid cysts and cysts in other locations may be cleared to fight under close medical supervision after review of ancillary tests such as a dedicated posterior fossa MRI in conjunction with an independent neuroradiologist and consideration of factors such as age of the boxer, fight record, prior history of concussions, size of the cyst, mass effect, prior hemorrhage, and relative compression of adjacent structures.
3. Boxers with arachnoid cysts who complain of headache in the immediate aftermath of a fight warrant close medical supervision and should not be discharged home from the venue. These boxers should be transported via on-site ambulance to the emergency department (ED) of the nearest Level 1 trauma center for emergent computed tomography (CT) of the head to rule out acute intracranial pathology such as a SDH in association with the arachnoid cyst and/or intracystic hemorrhage.
4. Boxers with arachnoid cysts who complain of headache, nausea and vomiting in the days following the fight (subacute and chronic phase), warrant neuroimaging to rule out subdural hygroma and SDH in association with the arachnoid cyst and/or an intracystic hemorrhage.
5. A boxer whose neuroimaging shows evidence of prior bleeding into the arachnoid cyst, increase in size of cyst compared to prior scans, or history of a SDH adjacent to the arachnoid cyst should be denied licensure to fight.

Discussion

Arachnoid cysts of the brain are usually congenital/developmental anomalies which form due to duplication or splitting of the arachnoid membrane. They contain cerebrospinal fluid with a

normal cellular and biochemical content and can occur in both the supratentorial and infratentorial location. They are seen commonly in the middle cranial fossa in young males and are usually incidental findings detected on neuroimaging. Patients with large arachnoid cysts may present with signs of raised intracranial pressure such as headache, nausea, and vomiting. A large arachnoid cyst may cause deformity of the calvarium in children by causing pressure erosion. Secondary arachnoid cysts may develop as a result of trauma or infection associated edema splitting the arachnoid membrane.¹

The association of arachnoid cysts with subdural hematomas has been known since the 1970s. It is believed that the relative decreased compliance of the cyst as compared to normal brain tissue predisposes to rupture of bridging veins after blunt force trauma to the head, as may occur during contact and combat sports. CSF pressure and flow dynamics may also be altered in arachnoid cysts predisposing to bridging vein failure and intracystic hemorrhage.^{1,2}

Subdural hematoma, subdural hygroma, and intracystic hemorrhage in association with an arachnoid cyst has been reported after occurrence of blunt force trauma in contact sports such as heading a soccer ball and football.^{3,4,5} Strahle et al. studied a total of 112 patients with arachnoid cysts who participated in 261 sports for a cumulative duration of 4410 months/1470 seasons. Out of the above, 94 patients participated in 190 contact sports for a cumulative duration of 2818 months or 939 seasons. They did not identify any serious or catastrophic neurological injuries in their cohort. Two patients (one, a 12-year-old girl after heading a ball during a soccer game and the second, a 16-year-old boy after a high-school football game) presented with symptomatic subdural hygromas. Both were managed conservatively and follow up imaging demonstrated either complete resolution or decreased size of the hygroma. The authors concluded that permanent or catastroph-

ic neurological injuries are rare in patients with arachnoid cysts who participate in athletic activities and opined that in most cases it is safe for patients with arachnoid cysts to participate in sports.⁶ Other neurosurgeons and sports medicine physicians are not so permissive and hold the opinion that patients with arachnoid cysts should not play contact sports.

It is important to remember that boxing is not just a contact sport, it is a combat sport. It is unique in the sense that every punch thrown at the head is thrown with the idea of winning by causing a knockout (KO) which is nothing but a concussion. As a result, concussions are common in boxing and sub-concussive injuries occur frequently during a bout or while sparring. Boxers with arachnoid cysts thus deserve close attention. This population has not been systematically studied and hence it is unknown how common SDH, subdural hygroma and intracystic hemorrhage are in boxers and other combatants with arachnoid cyst.⁷ The Amateur Boxing Association of England currently does not allow a boxer with arachnoid cyst to continue boxing, but also does not require a CT scan during the boxer's initial medical examination for licensure. In professional boxing, boxers fight without any protective headgear. Professional boxing in the United States is regulated by various state athletic commissions. These commissions have varying neuroimaging requirements for initial licensure. In some states, a detailed 1.5 Tesla (T) or 3T MRI scan is requested, others request a CT scan and in some states no screening neuroimaging is required at the time of initial licensure. There are also no consistent recommendations with respect to arachnoid cysts. In most cases determination of licensure for boxers with arachnoid cysts is made by the assigned physician on a case-by-case basis. Ringside physicians should be aware of the risks of SDH, subdural hygroma, and intracystic hemorrhage in association with arachnoid cysts. Evidence-based medical recommendations with respect to arachnoid cysts and participation in combat sports like boxing and MMA are needed.

Conclusion

The above proposed recommendations on arachnoid cysts and risk of boxing-related brain injury should be debated vigorously by the ringside physician community and be further refined by conducting well-designed studies on boxers with arachnoid cysts. Evidence-based medical recommendations should then follow.

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