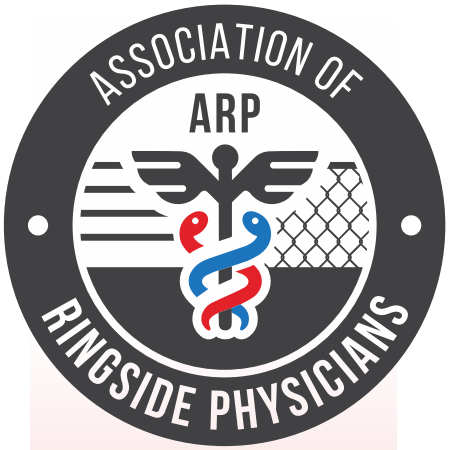

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From the Editor's Desk

Dear Colleagues,

The impact of COVID-19 on the combat sports industry has now started to abate. Attendance at events is back to pre-pandemic levels. In this issue of the *ARP Journal of Combat Sports Medicine*, Groen et al. present an interesting case of a 26-year-old MMA fighter who presented with umbilical pain following a kick to the stomach and subsequently deteriorated. The fighter was found to have active arterial hemorrhage from a previously unknown horseshoe kidney and emergency angio-embolization of two pseudoaneurysms was performed. Pain abdomen after blunt force trauma should not be dismissed by ringside physicians and if indicated should prompt further work-up with appropriate radiological modalities. Weinstein and Sethi present the results of their survey of college athletes. They identified a number of misconceptions surrounding concussion in this educated cohort of college students highlighting the importance of initiatives for concussion-related education. Lastly Sethi, in his commentary discussed the neurological considerations in an older combatant (>40 years of age).

I trust you shall find Volume 5 issue 1 of the *ARP Journal of Combat Sports Medicine* interesting and educational. Our two Senior Editorial Managers, Lisa Nelson and Susan Rees, 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 a very happy summer 2022.

Sincerely,

Nitin K Sethi, MD, MBBS, FAAN

MMA FIGHTER WITH A HORSESHOE KIDNEY MALFORMATION: BEWARE OF THE CIA!

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Abstract

Purpose: Mixed martial arts-related sport injuries comprise only a small fraction of blunt abdominal trauma patients presenting at the emergency department, mostly minor, well located, and, according to the literature, involving the colon.

Case Report: We present an atypical case of a 26-year-old MMA fighter with initial negligible umbilical pain following a kick to the stomach, who was triaged as minor trauma at our emergency department. The patient subsequently deteriorated due to an isthmal (grade IV) rupture of an unknown horseshoe kidney with an active arterial hemorrhage, shown on thin slice, multi-detector CT, for which emergency angio-embolization of two pseudo-aneurysms was successfully performed.

Conclusion: Uncommon presentations of common traumatic injuries should always prompt clinical suspicion and prudent utilization of appropriate additional radiological modalities. In most cases presenting at the emergency department, CT should be the logical next step, not only diagnostically but–as was presented in our case –also for therapeutical planning purposes and especially prior to non-operative management like angio-embolization because of possible aberrant anatomical variations. Furthermore, it might be feasible to consider low-threshold screening of competitive athletes in combative sports by way of abdominal ultrasound.

Introduction

Blunt abdominal trauma (BAT) is a common presentation in the emergency department (ED) with an incidence of 7-10% of all traumatic injuries[1] and is, in most instances, the result of high-energy mechanisms such as motor vehicle collisions resulting in hollow viscus rupture, parenchymal organ hematoma, or vascular injury.[2] Other causes range from falls from heights to sporting injuries.[3] Of the latter, martial arts (MA)-related trauma encompasses only a small fraction, mostly involving bouts of full-contact MA like kickboxing[4] and Jujitsu[5] and typically involving the colon.

Diagnostical and interventional radiology play an increasing role in the workup following BAT, with the latter steadily gaining ground on surgical intervention in more than selected cases.[6] Congenital disorders or anatomical variations of parenchymal organs can compose both diagnostic and therapeutical challenges stemming from deviant presentation of symptoms and aberrant anatomy complicating the surgical or endovascular approach. Descriptions of variations of the normal human anatomy share an evolution with important radiological innovations of the past half century.

Horseshoe kidneys (HK) are prone to traumatic lacerations following BAT because of the isthmus joining the lower poles in midline across the spine.[7] And although it was first described during autopsies, as early as 1522 by da Capri,[8] nowadays the diagnosis is usually made by either US or CT and because of its asymptomatic nature, generally incidental. The genetic etiology behind the abnormal horseshoe-like formation of the kidneys is believed to be multifactorial, and possibly due to abnormal migration of nephrogenic cells, alcohol consumption during pregnancy, or even more structural factors like flexion/rotation positions of the caudal fetal spine. Despite being the most common fusion defect of the kidneys, the overall incidence among the general population is still just around 0.25%. The various vascular deviations, summarized by Eisendrath et al.[9] are as follows:

- normally located arteries (19%);
- normally located arteries + one for the isthmus arising from the aorta (29%);
- two arteries for each half and one for the isthmus arising from the aorta (18%);
- two arteries for each half arising either from the aorta or the iliac arteries and one or two to the isthmus arising from the iliac arteries (14%); and finally
- Six to eight aberrant arteries arising from both the aorta and iliac arteries supplying the two halves (19%).

Case Report

We present the case of a 26-year-old male mixed martial artist (MMA), brought in at our ED around 11:00 pm, approximately 3 hours after sustaining two rapid consecutive kicks to the central abdomen during an officially regulated match. Although initially able to finish the match, increasing umbilical shooting pains forced the patient to return home immediately after, switching his own transportation for ambulance transport to the nearest hospital, midway. Because of the initial presentation upon arrival, the patient was triaged as minor trauma, which in our institution constitutes assessment by the ED personnel instead of the full trauma team. The patient showed signs of nausea with vomiting and expressed extreme umbilical pain. Despite a single spell of hypotension (80/40 RR) which responded well to a bolus of 250 cc NaCl, the patient was hemodynamically stable and received 7.5 mg of intramuscular morphine injection with oxynorm 5 mg for breakthrough pain. He had no relevant medical history and showed no signs of fever, rigors, hematemesis, melena, flank pain, or urinary symptoms, including hematuria. Vital signs remained normal despite a slightly elevated BP of 154/70 mm Hg and his physical examination only showed superficial abdominal excoriations besides extreme umbilical abdominal tenderness on palpation. His baseline hemoglobin level was 7.3 mmol/l, with otherwise normal lab results.

The diagnosis of abdominal free fluid was made by focused assessment with sonography in trauma (FAST), and subsequently a contrast-enhanced-multi-detector abdominal CT (eMDCT) with arterial and venous contrast phases was performed. The CT confirmed the extensive intra-abdominal haemmorhage and thin-slice arterial (1 mm) coupes showed a grade IV laceration of the centrally lying HK isthmus accompanied by an isthmal arterial blush originating from the left of the two aberrant arteries stemming from the respective bilateral common iliac arteries (Fig 1). A follow-up hemoglobin level showed a two-point

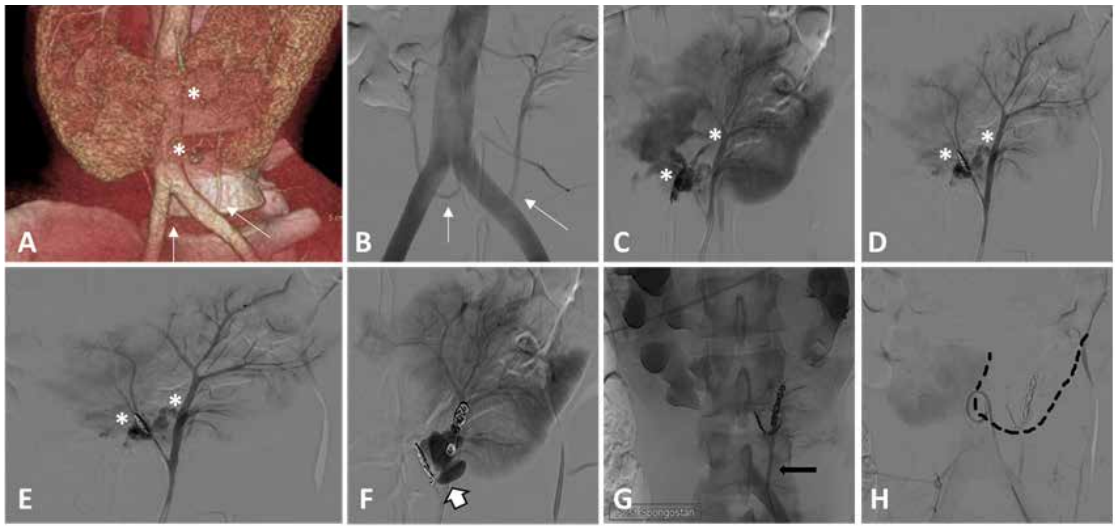

Figure 1: The 3D reconstruction of the arterial phase CT and the angiogram overview shows the Horseshoe kidney spanned across the aorta/lumbar vertebrae with the two aberrant arteries (small arrows) originating from the bilateral iliac artery (A,B). Two arterial pseudoaneurysms were found and subsequently coiled (asterixis), which originated from the main vessel and a right sided side branch (C, D, E). An additional contrast extravasation (large arrow) proximal from the coiled side branch appeared on control angiogram, and was successfully thrombosed after Spongostan administration prior to the bifurcation (large bold arrow) (F, G), thereby accepting infarction of the left sided ishtmal renal part, as is highlighted by the dotted line (H).

drop to 5,1 mmol/l and the patient received two erythrocyte concentrates and was elected to proceed with endovascular intervention.

Based on the results of the CT scan, and the subsequent precognition of the aberrant vascular anatomy, we chose for a left femoral approach instead of the usual right sided approach. This provided us a more adequate route to the culprit isthmal artery. Femoral arterial access was obtained using a 5 Fr sheath and aortography showed the horseshoe kidney with two aberrant arteries coursing bilaterally from the respective common iliac arteries (CIA) to the ipsilateral paramedian part of the isthmus and approximately one-third of the distal lower renal poles. Selective catheterization of the left aberrant isthmal artery was performed with an angled Progreat® 2.9 microcatheter and showed a distal prelobar side branch with two small bilateral pseudoaneurysms stemming from the intralobar part of both the side branch and the main vessel. The microcatheter was advanced using a Transcend® 0.014 microguidewire and both the side branch and the main vessel pseudoaneurysms were successfully embolized using Vortex 18 coils (side branch: 6x 2.5 mm/ main vessel: 6x 5.5 mm). Conformational arteriography of the left aberrant isthmal artery showed a remaining arterial blush originating from the side branch and the decision was made to scarify the left paramedian part of the isthmus by way of embolization of the left ishtmal artery just prior to the side branch using 25 mg Spongostan®. Subsequent angiography showed no residual extravasation from either the aberrant nor the native vascular arteries.

Hemodynamic parameters remained stable and no anesthesiology support was necessary. No systemic heparinization was performed. In the follow up the patient made a slow recovery, characterized by bilateral ureteric compression due to a slowly absorbing retroperitoneal hemorrhage for which bilaterally placed decompressive double-J-stents were removed after 4 months. Symmetric renal function remained with a GFR of 89 ml/min.

Discussion

The HK is a rare anomaly occurring in approximately 1/400 people.[10] Due to its vulnerable midline isthmus and the inability of each kidney to rotate and ascend to its normal position where it

is protected by the ribcage, it is prone to injury resulting from BAT,[8] with 7% of renal injuries following BAT occurring in kidneys with congenital or acquired disorders. The causes of blunt renal trauma in general are reported to be motorcycle- or car accidents, sport injuries, falls and assaults,[11] where it is debatable whether MA-related injury should fall under sports- or assault- related injury. This is the first case of BAT of a horseshoe kidney reported following a MMA match with notable previous case reports from Boninsegne et al.,[12] and Cortese et al.,[13] reporting on falls and car accidents respectively, and two recent systematic reviews on MA-related injuries mainly reporting trauma to the head and upper extremities with none-specified abdominal injury ranging 0.2-0.5%.[14, 15] This low incidence rate of serious BAT following MA and the normotensive presentation of the patient might have contributed to the initial triage as a minor trauma and the omission of admission by the trauma team as is normal practice following high-energy vehicle collisions. Furthermore, it is the authors opinion that the presentation of midline umbilical pain was the most elusive part of the presentation, which – short of the eMDCT – would not have led to the diagnosis and the subsequent endovascular therapy.

In revised versions of the AAST classification, segmental renal vascular injury is graded as level IV injury, despite the depth of the laceration. Non-operative-management (NOM, which includes angioembolization) of grade IV-V kidney lacerations is successful in 83-89% with indications for surgical intervention ranging from hemodynamically unstable patients to platelet-transfusion necessity and advanced age (> 55).[6] Other factors determining the treatment are additional injuries, with minimally invasive procedures like stent placement in the case of ureteral injury or urinoma formation. In addition to qualitative assessment of the extend of renal injury, eMDCT serves the purpose of evaluation of the often (60-80%) aberrant vascular anatomy, pre-embolization. Herein, the previously reported summarization of Eisendrath et al.[9] can serve as a guideline but judicious use of diagnostic angiography of all the vessels prior to embolization is advised since supernumerary vessels <3 mm in diameter are seen significantly more often in horseshoe kidneys versus normal kidneys (92.3% vs 33% respectively).[16] Our patient presented with bleeding from two branches of a segmental isthmal artery directly following a bifurcation from a left common iliac artery origin. Although super-selective catherization and microcoil delivery was initially attempted it is the authors' belief that our decision to sacrifice the left paramedian isthmal part of the HK, by way of Spongostan coagulation was in this case defendable against the risks of re-interventions and related complications.

Conclusion

The three equally uncommon dimensions of traumatic injury of a horseshoe kidney following BAT in a MMA fighter makes this a rare case worth reporting. It is important to remember that martial art-related injuries although commonly perceived – and in our case triaged as – minor trauma, may in fact obscure more serious intra-abominable trauma. Furthermore, unknown congenital anomalies can cause deviant presentation of signs and symptoms, for example pain localization in the midline in our case of a patient with a HK and throw off the clinician, thereby causing a unnecessary delay in appropriate treatment. eMDCT is of outmost importance in any suspected case of BAT for classification and therapeutical planning purposes, especially prior to non-operative management like angio-embolization because of the known aberrant vascular variations. Finally, it might be worth considering issuing a low-threshold screening protocol of competitive athletes in combative sports by way of abdominal ultrasound to account for certain anatomical variants that might change the differential diagnosis when examining a fighter with abdominal complaints following BAT.

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PRESENCE OF CONCUSSION MISCONCEPTIONS IN A COLLEGE STUDENT SAMPLE: RESULTS OF A SURVEY

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KEYWORDS: concussion, college sports, misconceptions

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Background

A leading cause of head injury in young adults ages 15-24 years is unintentional head impact exposure with another person or object.[1] In 2019, about 15% of high-school students in the United States self-reported sport- or recreation- related concussion(s) in the preceding 12 months;[2] however, we still lack a single unified definition of concussion. Definitions put forth by various professional organizations such as the American Academy of Neurology (AAN) (alteration of mental status due to biomechanical forces affecting the brain) and the American Association of Neurological Surgeons (AANS) (clinical syndrome characterized by immediate and transient alteration in brain function, including alteration of mental status and level of consciousness, resulting from mechanical force or trauma) have subtle yet significant differences. Of note, the definition provided by the AAN does not require a loss of consciousness. In the absence of a unified definition of this most common type of traumatic brain injury, the term "concussion" has been used loosely in both medical and non-medical literature. Recent studies have demonstrated concussion incidence increasing specifically in adolescents. A 2016 descriptive epidemiological study found concussion incidence was highest in patients between 15 and 19 years old (16.5 concussions per 1000 patients). Concussion incidence was also high in patients 20 to 24 years old (5.2 concussions per 1000 patients), and no age group above 25 years had a frequency of concussion higher than 3.1 per 1000 patients.[3]

Educating students and athletes on traumatic brain injury has been described as a vital step in not only preventing concussions, but also in protection from the debilitating short- and long-term effects of this most common type of brain injury. Recent research demonstrates the current level of concussion knowledge is insufficient and likely one of the reasons for underreporting and varied treatment of acute phase sports-associated concussions (SAC). These same studies suggest that future prevention initiatives should revolve around concussion-based education of athletes and the public.[4] Questionnaire-based studies are vital in gauging the depth of knowledge within age groups most prone to concussions, such as college students.

To gauge college students' understanding of concussion, we administered a 9-question survey to 54 college students in 2021. Results of the study provided varying responses as to how a concussion is defined, the association of the loss of consciousness to concussion, as well as various misconceptions relating to the difference between traumatic brain injury and concussion. The goal of this study, therefore, was to administer a larger, distinct and more specific questionnaire to an expanded cohort to determine what other misconceptions surrounding concussion exist in educated collegiate students.

Methods

A Google Forms questionnaire consisting of 21 questions was administered to 91 college students aged 18 to 23 years old. The Rosenbaum Concussion Knowledge and Attitudes Survey (RoCKAS) is a peer-reviewed questionnaire frequently used to assess knowledge and attitudes towards concussions.[5] The current survey differs from the RoCKAS as it was designed not only to gauge the students' overall understanding of concussions, but also to identify common misconceptions surrounding this most common type of head injury.

The questionnaire placed more complex, tedious, and long questions towards the end to improve response rate.[6] Questions included in the survey were asked in the form of either multiple choice (including "true or false" response types) or short text responses. Each question was selected with the objective of uncovering whether a specific misconception surrounding concussion or a related topic, existed in this educated cohort of young adults.

The sampling technique utilized was based on convenience to the author. Survey dissemination was performed strictly by telephone, manually, with daily reminders provided by first author. The survey consisted of 21 total questions (Table 1). Questions 1 through 20 received 91 responses. Question 21 did not achieve 100% response rate, and instead recorded 86 responses as it was not required for survey submission until the seventh response was completed.

To determine whether prior concussion was a factor that influenced student knowledge, the number of correct responses per question was recorded and separated into two groups: Students reporting history of concussion and students reporting no history of concussion. General descriptive statistics were used to examine the association of prior concussion history with knowledge of concussion misconceptions.

The 91 students enrolled in the study currently attend one of the following accredited United States universities: Cornell University (64), University of Wisconsin-Madison (8), University of Michigan (5), Texas Christian University (3), Northwestern University (2), Northeastern University (2), University of Miami (2), Johns Hopkins University (1), University of Pennsylvania (1), Duke University (1), Colgate University (1), Emory University (1).

Table 1. "Expanded College Student Survey: Concussions" Questions

Question #	Question	Response Type and Answer Options
1	"Have you played a sport in the past?"	Multiple Choice: "Yes" OR "No"
2*	"If you answered yes above, what was the highest skill level?"	Multiple Choice: "Recreational" OR "JV/Varsity" OR "Intramural/Club" OR "College Level"
3	"Have you ever experienced a concussion?"	Multiple Choice: "Yes" OR "No"
4	"Typically, how long does the risk of serious brain injury last after suffering a concussion?"	Multiple Choice: "1 hour" OR "4 hours" OR "24 hours" OR "48 hours" OR "Indefinitely"
5	"Are drowsiness and a worsening headache reliable signs of concussion?"	Multiple Choice: "Yes" OR "No"

(Table continued right)

Table 1 (continued). "Expanded College Student Survey: Concussions" Questions

Question #	Question	Response Type and Answer Options
6	"Are dilated pupils a reliable sign of concussion?"	Multiple Choice: "Yes" OR "No"
7	"TRUE OR FALSE: A mouthguard can help to prevent concussions."	Multiple Choice: "True" OR "False"
8	"TRUE OR FALSE: Risk of concussion can be lowered by the brand, age or style of a helmet/mouthguard."	Multiple Choice: "True" OR "False"
9	"Is complete rest best for recovery from a concussion?"	Multiple Choice: "Yes" OR "No"
10	"TRUE OR FALSE: After suffering a concussion, children should avoid digital media completely until feeling better."	Multiple Choice: "True" OR "False"
11	"TRUE OR FALSE: You must rest in a dark room to recover from a concussion."	Multiple Choice: "True" OR "False"
12	"TRUE OR FALSE: Males and females are at the same risk for a sports-related concussion."	Multiple Choice: "True" OR "False"
13[a]	"Select all of the following that can be used to diagnose a concussion."	Multiple Choice: "Symptoms (E.g. headaches, emotional symptoms)" OR "Physical signs (E.g. amnesia)" OR "Hit to the head occurred" OR "Signs of cognitive impairment" OR "Sleep impairment" OR "Behavioral changes"
14	"In 1-2 sentences, how would you define a MRI scan?"	Short Answer Text
15	"In 1-2 sentences, how would you define a CT scan?"	Short Answer Text
16	"TRUE OR FALSE: MRI scans are useful when diagnosing a concussion."	Multiple Choice: "True" OR "False"
17	"TRUE OR FALSE: CT scans are useful when diagnosing a concussion."	Multiple Choice: "True" OR "False"
18	"Does a person who suffers a concussion have to go to the emergency room?"	Multiple Choice: "Yes" OR "No"
19	"TRUE OR FALSE: Immediately after suffering a concussion, a person can take over-the-counter acetaminophen (e.g., Tylenol) or ibuprofen (e.g., Advil) to alleviate pain."	Multiple Choice: "True" OR "False"
20	"Can a person who recently suffered a concussion perform light activity?"	Multiple Choice: "Yes" OR "No"
21	"When is the earliest time a person should resume light activity after suffering a concussion?"	Multiple Choice: "< 24 hours after" OR "1-2 days after" OR "3-5 days after" OR "5-7 days after" OR "1-2 weeks after" OR "1 month after" OR "> 1 month after"

* Question did not require an answer to submit the survey
a. Question permitted the selection of more than one choice

Results:

The results of the questionnaire are recorded in Table 2.

Table 2. "Expanded College Student Survey: Concussions" Responses

Question #	Number of Responses	Responses
1	91 out of 91	Yes 91 (100%) No 0 (0%)
2	91 out of 91	Recreational 1 (1.1%) High School JV/Varsity 83 (91.2%) Intramural/Club 1 (1.1%) College Level 6 (6.6%)
3	91 out of 91	Yes 43 (47.3%) No 48 (52.7%)
4	91 out of 91	1 hour 1 (1.1%) 4 hours 4 (4.4%) 24 hours 12 (13.2%) 48 hours 17 (18.7%) Indefinitely 57 (62.6%)
5	91 out of 91	Yes 85 (93.4%) No 6 (6.6%)
6	91 out of 91	Yes 75 (82.4%) No 16 (17.6%)
7	91 out of 91	True 60 (65.9%) False 31 (34.1%)
8	91 out of 91	True 78 (85.7%) False 13 (14.3%)
9	91 out of 91	Yes 72 (79.1%) No 19 (20.9%)
10	91 out of 91	True 81 (89.0%) False 10 (11.0%)
11	91 out of 91	True 56 (61.5%) False 35 (38.5%)
12	91 out of 91	True 39 (42.9%) False 52 (57.1%)
13[a]	91 out of 91	Symptoms 90 (98.9%) Physical signs 87 (95.6%) Hit to the head occurred 85 (93.4%) Signs of cognitive impairment 91 (100%) Sleep impairment 85 (93.4%) Behavioral changes 85 (93.4%)

(Table continued right)

Table 2 (continued). "Expanded College Student Survey: Concussions" Responses

Question #	Number of Responses	Responses
14[b]	91 out of 91	Keyword(s)[c]: "Scan of Body(19)/Organs(8)/Insides(4)/Internal anatomy(4)" 35 (38.5%) Using: "magnetic waves/fields" 8 "magnetic imaging" 4 "radiation" 1 n/a* 22 "Scan/Image of Brain" 18 (19.8%) "tissue" 4 "activity" 2 "to see traumatic injury/anomalies" 2 "bleeds" 1 n/a* 9 "Scan of Tissue(6)/Muscle(4)/Non-bone(3)" 13 (14.3%) And: bones 3 tendons 1 ligaments 1 organs 1 damage 1 n/a* 6 "Deep/Intensive X-ray" 9 (9.9%) Other** 16 (17.6%)
15[b]	91 out of 91	Keyword(s)[c]: "Scan of Brain" 30 (33.0%) "bleeding" 4 "function" 2 "activity" 2 "electric activity" 2 "using radiation" 1 n/a* 19 "X-ray" 17 (18.7%) Of: "image/inside/internal of body" 7 "bones" 2 "many angles" 2 "organs" 1 "brain tissue" 1 n/a* 4 "Scan of Body(8)/Internal(2)/Organs(1)" 11 (12.1%) "Unsure" 8 (8.8%) "Like MRI" 8 (8.8%) But: "for the brain" 2 "less accurate" 2 "a different technique" 1 "for organs" 1 "an X-ray" 1 "more thorough" 1 "Medical/Static/Radiation Image" 4 (4.4%) "Scan for fractures/bone-breaking damage" 2 (2.2%) Other** 11 (12.1%)
16	91 out of 91	True 49 (53.8%) False 42 (46.2%)
17	91 out of 91	True 67 (73.6%) False 24 (26.4%)
18	91 out of 91	Yes 31 (34.1%) No 60 (68.2%)
19	91 out of 91	True 45 (49.5%) False 46 (50.5%)

(Table continued)

Table 2 (continued): "Expanded College Student Survey: Concussions" Responses

Question #	Number of Responses	Responses
20	91 out of 91	Yes 53 (58.2%) No 38 (41.8%)
21	87 out of 91	< 24 hours after 2 (2.3%) 1-2 days after 13 (14.9%) 3-5 days after 29 (33.3%) 5-7 days after 12 (13.8%) 1-2 weeks after 27 (31.0%) 1 month after 2 (2.3%) > 1 month after 2 (2.3%)

a. Question permitted selection of more than one choice (responses sum to >100%)
b. Short Answer Text response type
c. Keyword(s) defined as a word/phrase appearing > 1 time in total responses. Keyword(s) recorded as frequency of occurrence from all responses
* "n/a" defined as responses only including keyword with no further explanation
** "Other" defined as definitions/keywords appearing < 2 times in total responses

43 of 91 total students reported having suffered a concussion in the past. The number of correct responses per group, as well as the difference between groups, is displayed in Table 3.

Discussion

All 91 students enrolled in this study reported having played an organized sport in the past, including 6 college level athletes (6.6%). This percentage of student athletes is consistent with that of Cornell University (5.81% student athletes), the most represented university within this cohort.[7] Eighty-three of the 91 students (91.2%) responded that their highest sport skill level was high school junior varsity/varsity.

Forty-three respondents (47.3%) reported having suffered a concussion in the past. Notably, the same question was asked in the study performed by the two authors in 2021, which reported a lower frequency (16 of 54: 29.6%) of students that had experienced a concussion at some point prior to said questionnaire.

Student Knowledge on Common Concussion Misconceptions

Various misconceptions surrounding the signs/symptoms, diagnosis, treatment and risks of concussion were identified within this cohort.

Risk of Long-term Brain Injury. Long-term risks of concussion include, but are not limited to, cognitive dysfunction, motor dysfunction and permanent disability.[8,9] The risk of more serious brain injury, such as acute traumatic brain injury including subdural and epidural hematoma, however, typically passes after 4 hours.[10] Only 4 of 91 students (4.4%) correctly identified that serious risk of long-term brain injury lasts for 4 hours. Most students (57: 62.6%) stated that risk of long-term brain injury after a concussion lasts "indefinitely."

Possible signs and diagnosis of a concussion. Eighty-five students (93.4%) correctly identified drowsiness and worsening headache as reliable signs for a concussion; however, a large majority (75: 82.4%) incorrectly responded that dilated pupils are also a reliable sign. Ninety, 87, 85, 91, 85, and 85 students correctly identified the presence of "symptoms," "physical signs", "hit to the head occurred", "signs of cognitive impairment", "sleep impairment", and "behavioral changes" (respectively) as clinical signs and symptoms a physician may use in diagnosing a concussion.

Significance of mouthguards and helmets. One important misconception present within this student population related to questions 7 and 8. Sixty students (65.9%) identified that mouthguards help prevent concussions, and 78 students (85.7%) agreed with the following statement: "risk of concussion can be lowered by the brand, age, or style of a helmet/mouthguard". It needs to be emphasized that, as of now, there is no validated scientific study that supports the notion that a custom fitted mouthguard prevents concussion.

Safety of activities after a concussion is diagnosed. Several misunderstandings equating concussion treatments to a lack of activity existed among the sample. Questions 9 through 11, 20, and 21 were used to determine the presence of this common type of misconception. Seventy-two (79.1%) and 56 (61.5%) students incorrectly identified that complete rest and the need to rest in a dark room (cocooning), respectively, are best for recovery from a concussion. Eighty-one respondents (89.0%) agreed with the following

Table 3. Student Response Correctness: History of Concussion

Question Number	Correct responses from students reporting history of concussion, n (%) of respondents (n = 43)	Correct responses from students reporting NO history of concussion, n (%) of respondents (n = 48)	Difference between groups (by percent)
4	3 (7.0%)	1 (2.1%)	4.9%
5	40 (93.0%)	45 (93.8%)	0.8%
6	8 (18.6%)	8 (16.7%)	1.9%
7	13 (30.2%)	18 (37.5%)	7.3%
8	6 (14.0%)	7 (14.6%)	0.6%
9	8 (18.6%)	11 (22.9%)	4.3%
10	4 (9.3%)	6 (12.5%)	3.2%
11	15 (34.9%)	20 (41.7%)	6.8%
12[a]	11 (44.0%)	10 (40.0%)	4.0%
13[b]	N/A	N/A	N/A
14[b]	N/A	N/A	N/A
15[c]	N/A	N/A	N/A
16	18 (41.9%)	24 (50.0%)	8.1%
17	12 (27.9%)	12 (25.0%)	2.9%
18	28 (65.1%)	32 (66.7%)	1.6%
19	24 (55.8%)	22 (45.8%)	10.0%
20	24 (55.8%)	29 (60.4%)	4.6%
21[d]	10 (24.4%)	19 (41.3%)	16.9%

a. 50 total individual responses were recovered. Sample size for "Concussion" group: n = 25. Sample size for "No concussion" group: n = 25.
b. Question required a short text response and therefore had no "correct response" to be quantified.
c. Question is unable to be quantified.
d. Question received 87 total responses. Sample size for "Concussion" group: n = 41. Sample size for "No concussion" group: n = 46.

statement: "After suffering a concussion, children should avoid digital media completely until feeling better." Further, 53 (58.2%) students correctly identified that a person who recently suffered a concussion can perform light activity. Question 21 served as a follow-up question: "When is the earliest time a person should resume light activity after suffering a concussion?" Twenty-nine of 87 students (33.3%) responded correctly (3-5 days). It should be noted that the incorrect answer of "1-2 weeks after" received 27 of the 87 (31.0%) overall responses.

Safety of activities immediately after suffering a concussion. Per question 18, 60 (68.2%) students correctly agreed that a person who suffers from a concussion does not have to go to the emergency room; however, there existed disagreement relating to the myth that Advil® and Tylenol® are safe to take after a concussion. During the first 24 hours (acute symptomatic phase) after suffering a concussion, drugs that can increase risk of bleeding such as ibuprofen (Advil®) should generally be avoided.[11] Forty-five of the 91 (49.5%) students answered that this over-the-counter drug is safe to take immediately after suffering a concussion.

Use of MRI and CT scans. Questions 14 and 15 were designed to ensure that students could define MRI and CT scans, respectively, prior to being asked whether they are useful in diagnosing a concussion. Per the United Kingdom National Health Service, a MRI scan is defined as "a type of scan that uses strong magnetic fields and radio waves to produce detailed images of the inside of the body," and a CT scan is defined as "a scan [that] uses X-rays and a computer to create detailed images of the inside of the body."[12,13] The sample population provided several varying responses as to how they would define a MRI and CT scan. Thirty-five (38.5%) and 11 (12.1%) students identified the MRI and CT scan, respectively, as scans of the inside of the body. Eighteen (19.8%) and 30 (33.0%) defined the MRI and CT scan, respectively, as a "scan of the brain," which is partially true. It is worth noting that 9 students (9.9%) incorrectly defined a MRI as some sort of "X-ray," and only 12 responses (13.2%) included "magnetic waves/fields" or "magnetic imaging", which is a vital aspect of a MRI scan's function. Further, 8.8% of respondents were unsure of the definition of a CT scan.

Concussions typically cause a functional impairment of the brain. In the absence of structural brain damage, MRI and CT scans are usually reported normal and hence often not considered useful nor medically indicated when diagnosing a concussion.[14] Within this sample, however, 49 (53.8%) and 67 (73.6%) students incorrectly responded that MRI and CT scans, respectively, are useful in the diagnosis of a concussion.

Male and Female Sports-Related Concussion Incidence. Thirty-nine of the 91 students (42.9%) incorrectly responded that the following statement was true: "Males and females are at the same risk for a sports-related concussion" (question 12). While scientific data with respect to particular sports are lacking, gender and sex differences in concussion incidence and outcome has been studied and show a woman's brain to be more susceptible to concussive injuries as compared to a male brain. Disparities in neck musculature, specifically head-to-neck stability, likely contribute to lower concussion biomechanical threshold in women as compared to men. Hormonal factors such as estrogens may also make women more susceptible to concussion and lead to more prolonged recovery time after a concussive injury.

Influence of Prior Concussion History on Concussion Misconceptions. Prior personal history of concussion was not predictive of knowledge about concussion misconceptions. Ten of 15 questions reported a correct response difference of less than 5.0% between the two groups. Further, only one question reported a difference greater than 10% (Table 3).

The highest difference between groups occurred in question 21, which asked respondents to identify the earliest time a person should resume light activity. 16.9% more students within the "No history of concussion" group answered this question correctly. The lowest difference between groups

occurred in question 8, which asked students to identify whether risk of concussion can be lowered by the brand, age, or style of a helmet/mouthguard. Only 0.6% more students (1) within the "No history of concussion" group answered this question correctly.

Conclusion

Most student athletes receive some concussion education, especially if they play organized sports at the college level. Further, most college athletes diagnosed with a concussion are exposed to associated symptoms, risk factors, and treatments throughout their recovery process; however, this does not contribute to an increase in concussion knowledge. Our study indicates that significant misconceptions surrounding concussion persists in the collegiate athlete student community. Dispelling these common misconceptions by educating college students, especially athletes, about the incidence, biomechanics, clinical presentation and management of traumatic brain injury is critical in reducing the incidence and improving clinical management of this common head injury.[15] More robust initiatives for concussion-related education should be implemented to help dispel the myths and misconceptions that exist surrounding this most common type of closed head injury.

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COMMENTARY

Neurological considerations in an older fighter

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KEYWORDS: Boxing; MMA; combat sports; head injuries; older fighter

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Many commissions in the United States identify combatants above the age of 40 as older combatants and classify them as high-risk fighters.[1] It is accepted that these combatants need closer neurological and cardiological evaluation to determine their fitness to fight at the time of the initial licensure. They also warrant close medical supervision during the bout and in the immediate aftermath of the bout. When to counsel these athletes to stop fighting and hang up their gloves to prevent long-term neurological sequelae is a challenging task due to lack of validated imaging and biofluid (blood and cerebrospinal fluid) biomarkers for concussion.

To determine brain fitness to fight, all combatants above the age of 40 should undergo the following imaging studies at the time of the initial licensure and periodically (every 3 years) thereafter:

1. Magnetic Resonance Imaging (MRI) of the brain with susceptibility weighted imaging (SWI) or gradient echo imaging (GRE).
2. Magnetic Resonance Angiogram (MRA) of the Brain.

Neuroimaging studies may be requested earlier than 3 years on a case-by-case basis.

Formal neurocognitive testing either via a neuropsychologist (pen and paper testing) or computerized testing such as ImPACT with a notation if any deterioration from the baseline (first) assessment (if available) is advised. For non-English speaking combatants, interpreter mediated testing or testing in native language is acceptable.[1]

Boxing is a unique sport in that every punch thrown at the head is thrown with the intention of wining by causing a concussive brain injury (knockout). As a result, acute traumatic brain injuries (TBIs) such as epidural hematoma (EDH), subdural hematoma (SDH), subarachnoid hemorrhage (SAH) and intracranial hematoma are common in combat sports. Subdural hematoma is the biggest cause of boxing related mortality.[2] The incidence of SDH increases with age and, as a result, older fighters warrant close medical supervision during and in the immediate aftermath of a bout. An older fighter who has suffered multiple head impact exposures, has complaint of headache, focal neurological findings, or Glasgow Coma Scale score of less than 13 should be transported by ambulance to the nearest Level I trauma center for urgent CT scan of the head.[3] A boxer who has suffered a knockout (KO) or technical knockout (TKO) loss as a result of a head shot or multiple

head impact exposures is administered a period of medical suspension. The goal of this suspension is to give the boxer ample time to recover from the acute neurological insult (concussion). The period of medical suspension though is not standardized across different commissions in the United States and abroad.[4] An older fighter needs more time to recover from a concussion as compared to a fighter in his early 20s. Hence ringside physicians should administer a longer period of medical suspension to older fighters.

Apart from acute traumatic brain injuries, there is considerable risk for chronic neurological injuries in combat sports. These injuries include chronic posttraumatic headache, chronic posttraumatic dizziness, chronic posttraumatic cognitive problems, posttraumatic seizures, posttraumatic Parkinsonism, and chronic traumatic encephalopathy (CTE) among others. Here, it is important to remember that CTE is not a disease that is unique to American football. Boxing medical literature is rich with description of clinical entities such as dementia pugilistica, punch drunk syndrome, slug nutty all which closely resemble what is now referred to as CTE.[5,6] The true incidence of chronic neurological injuries in combat sports remains unknown as these injuries usually become known when combatants are in their late 40s or 50s long after they have retired. Recent research suggests that CTE behaves like a neurodegenerative disease which, once established, progresses over time. In combat sports, combatants sustain numerous head impact exposures both during training (sparring) and actual fights. Since multiple head impact exposures is the main risk factor for CTE, the burden of CTE in combatants is high but has gone unrecognized or ignored by the medical profession.

Older combatants need neurological evaluation and timely prognostication with respect to the above-mentioned chronic neurological injuries and sequelae of multiple concussive injuries of the brain. This can be accomplished best by a multimodal approach involving serial (periodic) neurological evaluations, neuroimaging preferably with MRI and neurocognitive evaluations. If concern for neurological decline is identified, the combatant should be red flagged and referred to an academic medical center for detailed evaluation which may include advanced neuroimaging modalities such as positron emission tomography (PET) scan and radionuclide dopamine transporter scan (DAT). Based on the results of these additional tests, the combatant may either be counseled to hang up his gloves and denied licensure to fight or may be allowed to continue fighting under close medical supervision.

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