

# Abdominal Crunch Syndrome Creates a Diagnostic Challenge in Treating a Pilot with Acute Upper Abdominal Pain

Ameet Kumar; Sumesh Kaistha

- BACKGROUND:** A diagnosis in acute abdomen may remain elusive especially when the cause is rare. We report this interesting case of a fighter pilot presenting with acute abdominal pain. The case posed significant challenges in reaching the correct diagnosis of abdominal crunch syndrome. The syndrome is rare with only seven reports in the literature so far. To the best of our knowledge, this is the first ever report of this condition in an aircrew.
- CASE REPORT:** A 37-yr-old pilot presented with severe upper abdominal pain and sweating. During examination, he developed bradycardia and was admitted with a presumptive diagnosis of acute coronary syndrome. Investigations revealed no myocardial ischemia on ECG, transaminitis, raised CPK, CKMB, and LDH. A CECT scan of chest and abdomen was normal. A GI surgery consult was sought where we connected the transaminitis and raised CPK and considered the possibility of rhabdomyolysis. On specific inquiry, the aviator gave history of unaccustomed exercise with a vigorous session of abdominal crunches a day prior. Thus, a diagnosis of abdominal crunch syndrome was concluded.
- DISCUSSION:** The aviator did not associate his vigorous exercise with the occurrence of pain and, therefore, did not mention it. It would have avoided unnecessary investigations and delay in treatment. From the aeromedical safety aspect, had the aviator flown on the day he developed pain, there was a possibility of developing severe pain exacerbated by the G force and G suit and sudden in-flight incapacitation. From the perspective of the aircrew, it is advisable that they avoid sudden, unaccustomed exercise.
- KEYWORDS:** acute abdomen, pilot, exertional rhabdomyolysis, rectus abdominis syndrome, aeromedical safety, in-flight incapacitation.

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Patients presenting with upper abdominal pain is one of the commonest emergencies presenting to the emergency department. The diagnosis is often surgical and sometimes medical and usually both specialties are involved in the evaluation of such patients. The surgical conditions could range from biliary colic or acute cholecystitis to peptic perforation and even aortic dissection. The medical conditions could be acid peptic disease or hepatitis to the more sinister pancreatitis or even inferior wall myocardial infarction. Thus, the evaluation of such patients, usually, proceeds in these directions. There are other uncommon causes of upper abdominal pain and, in such cases, there is usually additional time taken before a definitive diagnosis can be arrived at. An abdominal wall condition leading to upper abdominal pain is exceedingly rare and is not entertained as a possibility, upfront, in the initial evaluation. We report this

interesting case of a fighter pilot presenting with acute upper abdominal pain which perplexed many clinicians before making the right diagnosis of abdominal crunch syndrome.

## CASE REPORT

A 37-yr-old fighter pilot presented with a history of severe upper abdominal pain with sweating of 12 h duration which

From the Command Hospital (Air Force), Bangalore, Karnataka, India.

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Address correspondence to: Ameet Kumar, Professor, Command Hospital Air Force Bangalore, Old Airport Road, Bangalore, Karnataka 560007, India; docam@rediffmail.com.

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was sudden in onset following intake of food. He denied any history of fever, nausea or vomiting, melena or hematemesis, jaundice, prodromal symptoms, or bowel or bladder symptoms. He denied any history of dark colored urine. He had not consumed alcohol in the last 72 h and denied any flying related stress. Clinically, he was afebrile with a pulse rate of 64/min which fell to 36/min on admission but was normotensive. He had no pallor, cyanosis, pedal edema, or icterus. Abdominal examination revealed tenderness in the epigastric region with guarding but no rigidity.

He was admitted to ICCU with a provisional diagnosis of acute coronary syndrome. A troponin T test was negative; ECG showed sinus bradycardia, but no evidence of myocardial ischemia and the 2-D Echo was normal. His blood investigations showed normal hemogram, deranged LFT [total bilirubin  $1.8 \text{ mg} \cdot \text{dL}^{-1}$  and direct bilirubin  $0.2 \text{ mg} \cdot \text{dL}^{-1}$ , aspartate transaminase  $542 \text{ U} \cdot \text{L}^{-1}$  (normal, 0–40); alanine transaminase  $453 \text{ U} \cdot \text{L}^{-1}$  (normal, 0–40), alkaline phosphatase  $42 \text{ U} \cdot \text{L}^{-1}$ , and high CKMB  $218 \text{ U} \cdot \text{L}^{-1}$  (normal, <190), CPK  $1312 \text{ U} \cdot \text{L}^{-1}$  (normal, <25), and LDH  $918 \text{ U} \cdot \text{L}^{-1}$  (normal, 225–450)]. His serum amylase was  $36 \text{ U} \cdot \text{L}^{-1}$ , blood urea nitrogen was 19, serum creatinine was  $1.0 \text{ mg} \cdot \text{dL}^{-1}$ , and serum sodium and potassium were 140 and  $4.4 \text{ meq} \cdot \text{L}^{-1}$ , respectively. At this time, the differential diagnoses considered were acute pulmonary thromboembolism, acute viral hepatitis, acute pancreatitis, mesenteric ischemia, acute intermittent porphyria, and hemolytic anemia. A medical gastroenterology consult was sought.

CT angiogram of chest and abdomen was done which ruled out pulmonary thromboembolism, acute pancreatitis, and mesenteric ischemia. Urine for porphobilinogen was negative. Viral markers were negative for acute viral hepatitis. Peripheral blood smear did not show any evidence of hemolysis and the hemoglobin electrophoresis and sickling test were negative for sickle cell trait. Test for G6PD deficiency was also negative. An upper GI endoscopy was normal.

With the diagnosis being elusive, a gastrointestinal surgery consult was sought on day 3 of admission. The entire history, clinical findings, and investigations were reviewed along with the patient. The raised CK, LDH, and transaminitis caught our attention. Further, the CKMB/CK relative index was less than 3, which indicated a skeletal muscle source. This was the tipping point which prompted us to take history of any unaccustomed exercise and the pilot confirmed that he had restarted exercises after a 3-mo break and had a vigorous session of abdominal crunches for 20 min a day prior to the onset of pain. But as he did not consider it significant, he did not bring it out in the initial history giving.

Based on the above, a diagnosis of exercise-induced abdominal wall rhabdomyolysis (abdominal crunch syndrome) was made. All cardiac medications were stopped and he was treated with hydration, analgesics, and rest. He recovered rapidly thereafter with progressively decreasing CK and transaminases levels and was discharged on day 5 of his admission. He was reviewed after 10 d when he had no complaints, his examination was unremarkable, and all his biochemical parameters had

normalized. He was returned straight to active flying thereafter without subjecting him to any period of observation.

## DISCUSSION

Exertional rhabdomyolysis (ER) is a well described condition following sudden and unaccustomed exercise. However, its presentation as upper abdominal pain has been rarely reported. Abdominal crunch induced rhabdomyolysis was first reported by Schmitt in 1983,<sup>12</sup> who termed it 'rectus abdominis syndrome' and there are only seven reports of it in the literature so far (**Table I**). To the best of our knowledge, this is the first ever report of this condition in an aircrew.

ER, in general, has usually been reported in military and paramilitary personnel because of the prolonged and intense physical activities undertaken, often in hot weather conditions and in military uniform. However, there are increasing reports of this condition in the civil population too. There is a paucity of data from Indian populations on ER, but data exists from western populations. Among civil populations, one study found a 5% incidence of ER among all cases of rhabdomyolysis. Two more studies reported 21 cases in 13 yr and 89 cases in 12 yr, respectively. Both studies were prompt to point out the majority of these cases occurred in the latter half of the study period and attributed it to increasing popularity of high-intensity work outs in the gym.<sup>5</sup> The incidence of ER has been found to vary between 0.3% in one group of marine recruits to 3% in a group of army officer candidates.<sup>1,11</sup> A Mayo Clinic study reported 20 times more incidence of ER in military personnel as compared to civilian cases.<sup>11</sup> One study showed that the occurrence of ER after severe exercise depended on the levels of preconditioning in variously trained healthy volunteers.<sup>8</sup> The study also showed that ER occurred earlier in the training period and was a function of the how well or less trained an individual was. It is postulated that the intense physical exertion leads to the exhaustion of the ATP molecules of the skeletal muscle cells, which drives dysfunction in the muscle cell membranes, thereby causing rhabdomyolysis.<sup>2</sup>

Acute abdomen is a Pandora's box with many differential diagnoses and, at times, it takes time and more investigations to come to a diagnosis. But the cornerstone of approach will remain meticulous history taking and clinical examination. The aviator did not associate his vigorous abdominal crunches with the occurrence of pain and did not mention it. If the history had been forthcoming in the initial evaluation, a lot of unnecessary investigations would have been avoided. Had it not been elicited later, it would have led to more investigations and probably the condition would have gone undiagnosed and could have led to a period of observation for him before he could be returned to flying. It would be pertinent to note that had the ER been severe, any further delay in diagnosis could have worsened his condition, possibly progressing to serious complications like acute kidney injury or disseminated intravascular coagulation.

**Table I.** Summary of All Cases of Abdominal Crunch Syndrome Reported in the Literature.

YEAR	AUTHOR	AGE/ SEX	PRESENTING COMPLAINT	INCITING ACTIVITY	CK LEVELS (U/L)	CKMB/CK RELATIVE INDEX	AST/ ALT (U/L)	LDH (U/L)	OUTCOME
1983	Schmitt <sup>12</sup>	19/M	Acute abdominal pain	Intensive body building exercises	22,388	0.1	90/35	973	Recovered well
1992	Reimers <sup>10</sup>	21/F	Acute abdominal pain	Ski gymnastics and sit ups	7800	CKMB value N/A	—	—	Recovered well
		18/M	Acute abdominal pain	Abdominal muscle training	13,860	CKMB value N/A	—	—	Recovering well, lost to follow-up
		20/M	Acute abdominal pain	Swimming and alcohol binge	17,500	CKMB value N/A	—	—	Recovered well
1998	Kao <sup>7</sup>	29/m	Anterior abdominal wall muscle pain	Vigorous sit ups for the past 5 d	12,586	0	—	149	Recovered well
1999	Haas <sup>6</sup>	23/M	Right upper quadrant abdominal pain	Abdominal crunches	53,000	CKMB value N/A	568/200	1294	Recovered well
2003	Dai <sup>3</sup>	—	—	—	—	—	—	—	—
2008	Chawla <sup>1</sup>	24/M	Abdominal pain and nausea	Abdominal crunches along with alcohol binge	29,536	CKMB value N/A	174/40	974	Recovered well
2018	Echague <sup>4</sup>	27/F	Abdominal pain and swelling over mons pubis	Intense powerlifting	5917	CKMB value N/A	221/176	—	Recovered well
2022	Present case	37/M	Severe upper abdominal pain and sweating	Abdominal crunches	1312	0.17	542/453	918	Recovered well

N/A: Not available.

Clinical diagnosis centers on history of intense physical activity with complaints of myalgia in the affected group of muscles and dark colored urine that is caused by myoglobinuria. Myoglobinuria is seen in about 50% of cases only.<sup>4</sup> Apart from meticulous history taking and examination, the lynchpin for the diagnosis of ER is elevated CPK and low CKMB/CPK ratio. Many studies have shown that ER is associated with transaminitis and the origin, which is myocytes rather than hepatocytes (Table I).<sup>9</sup> Our patient too had transaminitis, apart from elevated CPK and LDH, which also pointed toward ER.

Notably, our case did not have dark colored urine. Probably the extent of ER was not enough to cause significant myoglobinuria. It is estimated that at least 100 g of muscle needs to be injured to produce a myoglobin level  $>25 \mu\text{g} \cdot \text{mL}^{-1}$  and which is the minimum level to color the urine dark brown or red.<sup>2</sup> Retrospectively, the severity of ER in our case was not severe and, consequently, he recovered quickly without requiring any major intervention except for hydration and analgesia with rest. Severe cases of rhabdomyolysis can result in fever, hypotension, confusion/delirium, acute kidney injury, metabolic acidosis, and dyselektrolytemia leading to life threatening arrhythmias. Treatment in these cases includes rapid hydration, mannitol administration, alkalization of urine, correction of dyselektrolytemia, and emergency dialysis. Fasciotomy is done if compartment syndrome occurs. Schmitt has termed this crunch-induced ER as rectus abdominis syndrome because the rectus abdominis is enclosed in a tight fascial compartment that provides little room for expansion of the muscle swelling caused by the intense exertion.<sup>12</sup> Thus, if the ER was severe, probably a fasciotomy might have been indicated.

If a history of unusual physical activity had not been forthcoming, the case would have been investigated for other causes of rhabdomyolysis, which includes alcohol, drug abuse (opiates, benzodiazepines, amphetamines, and recreational drugs like 'ecstasy'), therapeutic drugs (corticosteroids, salicylates, statins, etc.), sickle cell crisis, metabolic myopathies (e.g., McArdles disease), or muscular dystrophies (e.g., Duchenne and Becker dystrophies). In the latter two conditions, muscle biopsy with immunohistochemical studies is indicated. However, our patient did not have a history suggestive of rhabdomyolysis in the past and did not suffer from similar episodes during his follow-up period. Thus, further investigation was not warranted in our case.

From the aeromedical safety aspect, it is pertinent to highlight that had the aviator flown on the morning of the day he developed abdominal pain, he would have developed this pain during his sortie. When he would have pulled high G, the G suit would have only further increased the compartmental pressure of the rectus abdominis, causing worsening of pain and resulting in sudden in-flight incapacitation.

This article underscores the importance of thorough history taking with a good clinical examination and scrutiny of all investigations ordered to pick up rarer causes of acute abdomen. ER or abdominal crunch syndrome, although rare, should be kept in the differential in any patient presenting with an acute abdomen. This will prevent a misdiagnosis, unnecessary investigations, and worsening of the condition for the want of a definitive diagnosis. From the perspective of the aircrew, it is advisable that they avoid sudden, unaccustomed exercise and resort to graded escalation of the severity of physical training.

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*Authors and Affiliations:* Ameet Kumar, M.S., M.Ch., Department of GI Surgery, Command Hospital Pune, Maharashtra, India, and Sumesh Kaistha, M.S., M.Ch., Department of GI Surgery & Liver Transplantation, Army Hospital (Research and Referral), New Delhi, India.

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