Cardiac arrest in a young man following excess consumption of caffeinated "energy drinks"

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An otherwise healthy 28-year-old man had a cardiac arrest after a day of motocross racing. He had consumed excessive amounts of a caffeinated "energy drink" throughout the day. We postulate that a combination of excessive ingestion of caffeine- and taurine-containing energy drinks and strenuous physical activity can produce myocardial ischaemia by inducing coronary vasospasm. (*MJA 2009; 190: 41-43*)

Clinical record

A 28-year-old male amateur motocross rider was admitted to Port Macquarie Base Hospital in August 2007 after having an out-of-hospital cardiac arrest. He had collapsed shortly after participating in a motocross race. An off-duty paramedic and nurse had been on hand, and effective cardiopulmonary resuscitation was commenced promptly. Paramedics arrived after about 20 minutes of resuscitation.

The patient's initial cardiac rhythm was recorded as ventricular fibrillation (Box 1). He was restored to sinus rhythm after receiving two 150 J biphasic direct-current shocks. Adrenaline 1 mg and atropine 1 mg were both given as adjuvants. He was intubated by paramedics and transported to hospital.

Later, the patient recalled feeling well earlier in the day, until after his second race, when he developed dull constant retrosternal chest pain. He described this as being mild in intensity, with no radiation or associated symptoms. It settled within 30 minutes of sitting down to rest. He went on to participate in (and win) one more race that afternoon. He collapsed at about 3 pm, approximately 20 minutes after the last race. There had been no symptoms immediately preceding the collapse that he could recall.

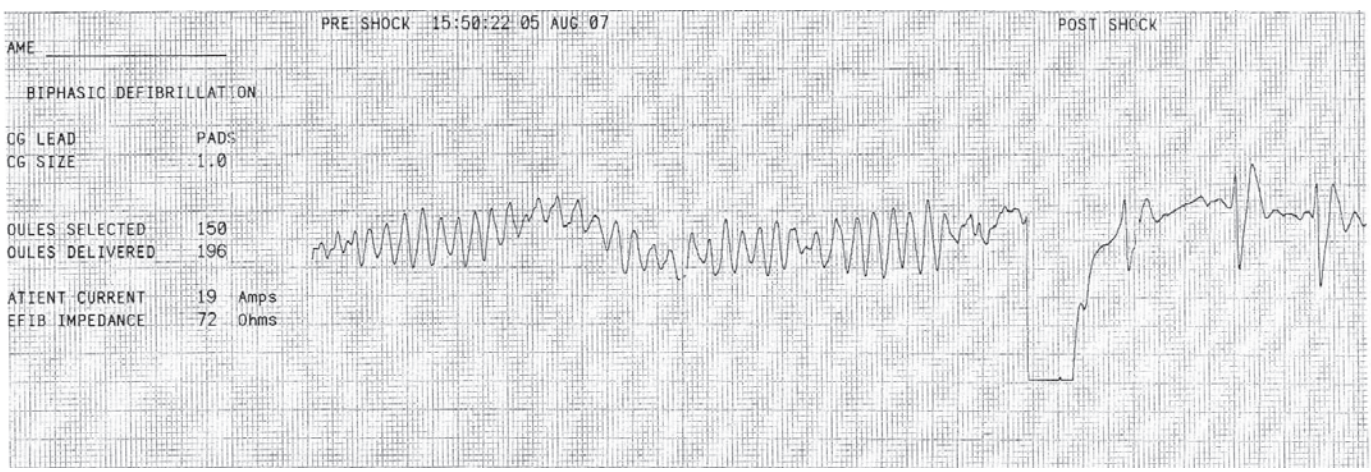
The patient had been well in the week preceding these events. He denied having any previous episodes of chest pain or syncope. He had a large breakfast on the morning of the motocross race and had remained adequately hydrated throughout the day. Further, he had consumed 7–8 cans of a caffeinated "energy drink" between 8 am and his collapse 7 hours later. He was otherwise fit and well and taking no regular medication. There was no family history of premature coronary disease, sudden cardiac death or unexplained syncope. He was a smoker with a six pack-year history of smoking. He denied alcohol misuse or illicit drug use.

On arrival at hospital, the patient was intubated and sedated. He was haemodynamically stable, and physical examination was unremarkable. An initial electrocardiograph (ECG) showed sinus rhythm and elevated anteroseptal ST segments with reciprocal inferior ST depression. Chest x-ray showed a normal cardiac silhouette and no signs of pulmonary venous congestion. Computed tomography scans of the chest and brain were unremarkable, specifically excluding aortic dissection. Abnormal findings from laboratory tests included an elevated level of troponin I (0.24 mmol/L; reference range [RR], < 0.05 mmol/L) and a lowered potassium level (3.0 mmol/L; RR, 3.6–5.4 mmol/L). Results of a urinary screen for drugs of misuse, including amphetamines and cocaine, were negative. Screening for anabolic steroids was not performed.

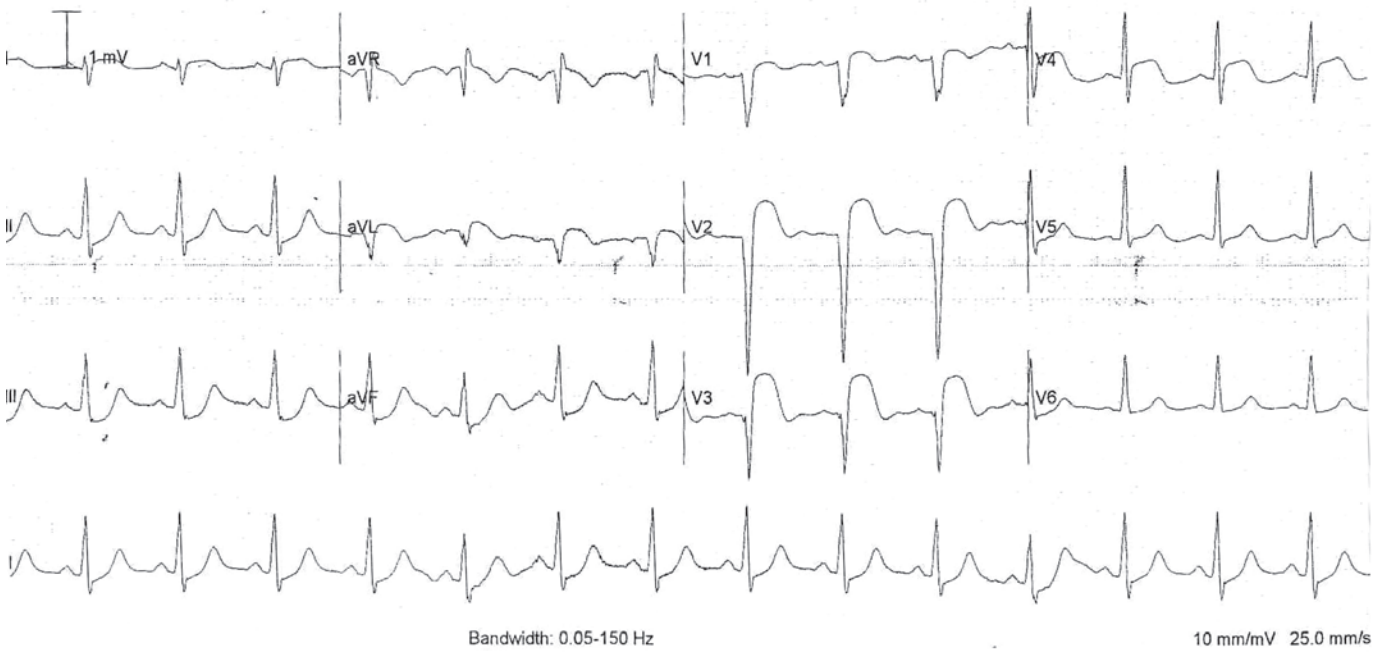
The provisional diagnosis was of anteroseptal ST elevation myocardial infarction. The patient was given thrombolysis with 50 mg of tenecteplase and commenced on an infusion of intravenous heparin. He was given loading doses of 300 mg of both aspirin and clopidogrel, and 25 mg of metoprolol, all by nasogastric tube. Hypokalaemia was corrected via intravenous infusion.

The patient was transferred to a tertiary referral centre for cardiac catheterisation. On arrival there, an ECG showed evolving ischaemic changes across the anterolateral leads (Box 2). A troponin I peak level of 12.2 mmol/L was measured; his potassium level had normalised at 4.0 mmol/L. Echocardiography showed

1 Patient's initial cardiac rhythm, showing ventricular fibrillation



2 Patient's electrocardiograph on arrival at tertiary referral centre, showing evolving ischaemic changes across the anterolateral leads



mild left ventricular enlargement and low-normal systolic function with a hypokinetic anteroseptal segment.

Coronary angiography, performed on the same day, gave normal results. No attempts were made during angiography to induce vasospasm. The patient was cooled for 24 hours and extubated without difficulty. He was discharged after 6 days. At discharge, he was taking atenolol 50 mg, aspirin 100 mg, spironolactone 25 mg and perindopril 2.5 mg.

On follow-up 2 months later, the patient reported that he had remained well and symptom-free. Echocardiography showed preserved global left ventricular function with a limited residual area of akinesis of the anteroseptal wall. He continued taking aspirin, perindopril and atenolol (reduced to 25 mg). He was advised not to compete in motocross races for 6 months, after which a stress echocardiogram was performed; this was negative for exercise-induced ischaemia.

Discussion

We postulate a possible role of excessive consumption of caffeinated energy drinks in triggering the life-threatening cardiac events described in this case.

Although sudden cardiac death is an uncommon occurrence in people under the age of 40 years, when it does happen it is most often associated with the presence of structural heart disease, most frequently premature coronary atherosclerosis. Other common associations are hypertrophic obstructive cardiomyopathy and myocarditis.[1,2] However, autopsy review studies have found that some 10%–12% of subjects in this age group have no obvious cardiac abnormalities on postmortem examination.[1,2] Of identified causes in this group, many are familial sudden cardiac deaths or disorders of conduction, such as Wolff–Parkinson–White syndrome.[3]

Our patient had electrocardiographic and echocardiographic features indicative of transmural ischaemia localised to the anterior territory. This is suggestive of a regional rather than a global process, and suggests an ischaemic event rather than a primary arrhythmia. However, the angiogram did not show any significant coronary lesions. Although non-stenotic atherosclerotic plaques may rupture or denude and cause infarction through the formation of superimposed thrombi, which may have then been dissolved by the administration of thrombolytics, we believe that — considering this man's relative youth — there is a distinct possibility that the underlying abnormality was coronary vasospasm.

An arrhythmia, possibly triggered by the ingestion of stimulants in the presence of hypokalaemia and physical exertion, was a differential diagnosis. However, this would not account for the regional abnormality seen. The cause of this patient's hypokalaemia is unclear, but may have been related to electrolyte losses from excessive sweating during exertion. This effect may have been exacerbated by the diuretic effect of caffeine.

The role of illicit stimulants, especially cocaine, in causing coronary vasospasm in young people is well established.[4] However, this patient denied cocaine use and returned a negative result on his drug test, making this an unlikely cause.

The energy drink consumed by our patient contains 80 mg of caffeine (equivalent to one cup of espresso) per can. He drank seven or eight cans within 7 hours — up to 640 mg of caffeine in total. The drink also contains high doses of taurine (an amino acid) and glucuronolactone (a glucose metabolite), neither of which are considered to have significant toxicity, although there is a paucity of data.[5,6]

Caffeine is a naturally occurring xanthine derivative related to theophylline; it has a number of potential pharmacological actions on the cardiovascular system. Its primary mechanism of action is

thought to be through competitive inhibition of adenosine receptors.[7] It also induces catecholamine release, and causes a rise in intracellular calcium in myocytes through release of calcium from the sarcoplasmic reticulum, leading variably to smooth muscle contraction and relaxation.[8-10]

The role of caffeine in triggering arrhythmia is well established.[8] There have been a number of case reports on hospitalisations or deaths due to caffeine toxicity, although the mechanism usually seems to be tachyarrhythmia and involves far higher doses than in this case.[11,12] The median lethal dose in rats is 200–400 mg/kg.[13] A 1997 case report described a young woman who suffered a myocardial infarction due to caffeine toxicity; however, this involved an oral dose of 20 g.[14]

In-vitro studies have shown that taurine has an inotropic effect on cardiac muscle similar to that of caffeine, and potentiates caffeine-induced muscle contracture. Few taurine toxicity studies have been performed, and there are insufficient data to suggest what an unsafe level of taurine consumption might be, if any.[9,14]

Both taurine and caffeine have been shown in vitro to have physiological effects on intracellular calcium concentration within vascular smooth muscle, and they could conceivably induce coronary vasospasm. In-vivo studies have demonstrated a capacity for caffeine to decrease myocardial blood flow during exercise.[15] We postulate that, in physiologically predisposed individuals, a combination of excessive ingestion of caffeine- and taurine-containing energy drinks and strenuous physical activity can induce myocardial ischaemia by coronary vasospasm, with potentially fatal results.

Caffeine has been removed from the list of prohibited substances in sport but remains on a monitoring program run by the World Anti-Doping Agency.[16] Anecdotal reports suggest that the many caffeinated energy drinks now on the market are widely used by amateur and professional athletes to enhance their performance. We are concerned that a combination of exercise and the caffeine contained in these drinks may have the potential to trigger serious cardiovascular events.

We accept that this is a single case, which does not and cannot establish causality. However, in the context of concerns reported in the media in recent years relating to similar events overseas, and in the presence of a plausible pharmacological mechanism, we believe that the potential dangers of these caffeinated energy drinks should be highlighted, and monitoring for future adverse events should be conducted.

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Competing interests

None identified.

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References

1 Drory Y, Turetz Y, Hiss Y, et al. Sudden unexpected death in persons less than 40 years of age. *Am J Cardiol* 1991; 68: 1388-1392.
2 Eckart RE, Scoville SL, Campbell CL, et al. Sudden death in young adults: a 25-year review of autopsies in military recruits. *Ann Intern Med* 2004; 141: 829-834.
3 Wever EF, Robles de Medina EO. Sudden death in patients without structural heart disease. *J Am Coll Cardiol* 2004; 43: 1137-1144.
4 Lange RA, Hillis LD. Cardiovascular complications of cocaine use. *N Engl J Med* 2001; 345: 351-358.
5 CBC News. In the can: Red Bull's ingredients dissected. http://www.cbc.ca/consumers/market/files/health/redbull/ingredients.html (accessed Jan 2008).
6 Australia New Zealand Food Authority. Inquiry report. Application A394: formulated caffeinated beverages. 8 August 2001. http://www.food-standards.gov.au/_srcfiles/A394_(full)_report.pdf (accessed Jan 2008).
7 Haller CA. Caffeine. In: Olson KR, editor. Poisoning and drug overdose. International ed. The McGraw-Hill Companies, 2007.
8 Mehta A, Jain AC, Mehta MC, Billie M. Caffeine and cardiac arrhythmias. An experimental study in dogs with review of literature. *Acta Cardiol* 1997; 52: 273-283.
9 Steele DS, Smith GL, Miller DJ. The effects of taurine on Ca^{2+} uptake by the sarcoplasmic reticulum and Ca^{2+} sensitivity of chemically skinned rat heart. *J Physiol* 1990; 422: 499-511.
10 Watanabe C, Yamamoto H, Hirano K, et al. Mechanisms of caffeine-induced contraction and relaxation of rat aortic smooth muscle. *J Physiol* 1992; 456: 193-213.
11 Holmgren P, Nordén-Pettersson L, Ahlner J. Caffeine fatalities — four case reports. *Forensic Sci Int* 2004; 139: 71-73.
12 Cannon ME, Cooke CT, McCarthy JS. Caffeine-induced cardiac arrhythmia: an unrecognised danger of healthfood products. *Med J Aust* 2001; 174: 520-521.
13 Organisation for Economic Co-operation and Development. SIDS [Screening Information Data Set] initial assessment profile: caffeine. Paris: OECD, Mar 2002. http://www.chemicals.moew.government.bg/chemical/site/File/registers/profile/58082p.pdf (accessed Jan 2008).
14 Forman J, Aizer A, Young CR. Myocardial infarction resulting from caffeine overdose in an anorectic woman. *Ann Emerg Med* 1997; 29: 178-180.
15 Baum M, Weiss M. The influence of a taurine containing drink on cardiac parameters before and after exercise measured by echocardiography. *Amino Acids* 2001; 20: 75-82.
16 World Anti-Doping Agency. The 2008 Monitoring Program. http://www.wada-ama.org/rtecontent/document/Monitoring_Program_2008_En.pdf (accessed Oct 2008).

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