## Fatal posture in anaphylactic shock

*To the Editor:*

Since 1992, I have studied details of 214 deaths associated with anaphylaxis. For 196 of these deaths there is sufficient information from the descriptions of events during the reactions and autopsy findings to determine that 88 were from shock (in 38 of these, shock was combined with difficulty breathing), 96 were from asphyxia (lower airway, 49; upper airway, 22; upper and lower airways or airway unspecified, 25), 7 were from complications of disseminated intravascular coagulation, and 5 were from the effects of epinephrine overdose.[1]

An important pattern has become clear from the 38 anaphylactic shock deaths that occurred outside hospital. In 10 of these cases, information was available to determine the postural history after onset of anaphylaxis. Four deaths occurred within seconds of a change to a more upright posture: in each of 2 cases of nut anaphylaxis, the individual stood up after sitting slumped or lying down; in 1 case of antibiotic anaphylaxis, the individual was made to sit in a chair after lying in bed; and in 1 case a driver stepped out of his vehicle during a reaction to a sting. In another 5 fatal anaphylactic reactions to stings and in another fatal reaction to an antibiotic, each individual had been supported sitting up after shock caused loss of consciousness. The postural history of the remaining 28 cases is unknown: nevertheless, the pattern being reported seems significant. It is unusual for patients to be supported upright while shocked; most shocked patients will either lie down or collapse. Patients with anaphylactic shock after being stung might recover consciousness while lying down, only to lose it again when they try to sit up: they therefore tend to remain supine while shocked.

A possible mechanism suggests itself to explain this striking pattern of sudden deaths after a change to a more upright posture. During anaphylactic shock, the capacity of the veins and capillaries expands greatly. While a shocked person is lying down, sufficient blood might return to the vena cava to maintain a reduced circulation, but on the person's sitting up or standing, this venous return stops; the vena cava will then become empty within seconds. There is then no flow through the right side of the heart, and within a few seconds more, no blood will return to the left side of the heart from the lungs. Pulseless electric activity continues, but in the absence of left ventricular filling there can be no contractions; this prevents coronary arterial flow and leads to myocardial ischemia. In less extreme cases, too, the coronary circulation, which is dependent on the diastolic pressure, is likely to become inadequate, because the blood pressure is the product of the cardiac output and the systemic vascular resistance, both of which are low in cases of anaphylactic shock.

If this hypothesis is correct, once the vena cava is empty, epinephrine—no matter where or how it is given—could not circulate and so could not reverse the shock; nor could external cardiac massage reestablish the circulation if there is no blood in the vena cava. Antishock trousers or volume replacement by intravenous infusion would help refill the vena cava; raising the legs is a simple and effective alternative. A recent study of shocked patients demonstrated that the greater the deficit in the intravascular circulating volume, the greater the improvement in blood pressure consequent on raising the legs[2]; one would thus expect this maneuver to be highly effective in severe anaphylactic shock.

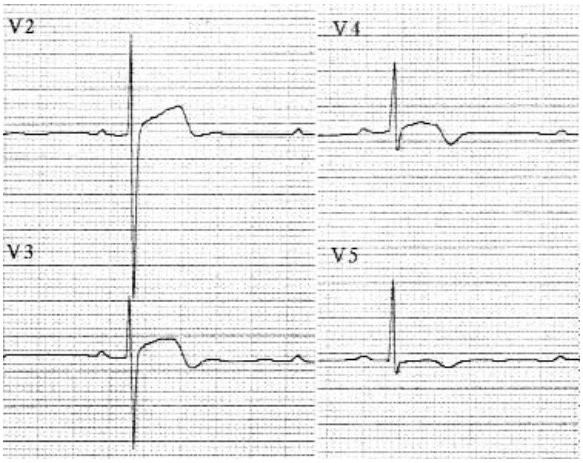


**FIG 1.** Electrocardiograph taken 6 hours after a hypotensive wasp sting reaction in a 52-year-old man.

Some specific observations are consistent with this hypothesis. In a case of fatal wasp anaphylaxis, an electrocardiogram performed by a paramedic shortly after consciousness had been lost while the patient was supported sitting up showed ST elevation and T wave inversion: this electric activity continued after loss of pulse. The deceased was a fit active man with no history of heart problems: autopsy revealed that the ischemia was unlikely to have been due to coronary artery disease. Fig 1 shows an electrocardiogram taken after arrival in hospital of an athletically fit man with no history of heart disease or hypertension who had sat up to use his EpiPen and remained sitting, semiconscious, during a hypotensive wasp sting reaction. He had no angina, and his subsequent exercise electrocardiogram was normal.

Previous reports have attributed ischemic changes after sting reactions to coronary artery spasm[3] or shock.[4] Either of these is possible, and the two might operate synergistically. Although coronary artery spasm has been directly observed in anaphylactic reactions during angiography,[5] the mechanism for reactions to contrast media is not fully understood and might differ from that for reactions to stings. Histamine infusion failed to cause coronary spasm in the absence of preexisting vasospastic angina,[6] but leukotrienes can increase coronary vascular resistance,[7] more likely by acting on the smaller vessels

rather than acting on the main coronary arteries. Whether the ischemia is due to increased coronary resistance, decreased diastolic pressure or both, lying down with the legs raised will help restore coronary flow.

The 50 shock deaths in hospital mostly occurred in the operating room after intravenous injection; these were quicker (median time to loss of cardiac output, 5 minutes; this compared with 15 minutes outside hospital), the cases commonly involved arrhythmia rather than pulseless electric activity, and the patients were invariably rapidly treated. These facts explain why a similar pattern was not observed in this group. However, myocardial ischemia/infarction was recorded during or after the reaction in 7 of these iatrogenic anaphylactic shock deaths; autopsy confirmed infarction in 2 patients who survived 5 and 20 hours but not in 1 patient who died less than an hour after the reaction. Of the 4 patients with no autopsy information, one was a fit 26-year-old who would not have been expected to have severe coronary artery disease. In comparison, none of the 96 asphyxial anaphylactic deaths in or out of hospital were reported to involve myocardial ischemia.

Although anaphylaxis can affect many organ systems, fatal reactions have commonly been due to one dominant modality: shock, asthma, or upper airway angioedema. Most of those with severe hypotension can lie down without undue difficulty in breathing. The time to arrest in fatal anaphylactic shock outside hospital in this study is between 4 and 80 minutes; for the majority of those who died, the time was between 10 and 20 minutes. Medical assistance often takes longer than this to arrive. In comparison, asphyxial deaths outside hospital took 10 to 360 minutes (median, 35 minutes) to first respiratory arrest: most of the individuals were standing, and none is known to have been lying down. Collapse was in some cases sudden, with loss of pulse; it is possible that in these cases prolonged extreme expiratory effort contributed to the collapse by preventing cardiac refilling.

A patient with anaphylactic shock should therefore be kept lying down, with the legs supported/raised to ensure that the vena cava is, insofar as possible, the lowest part of the body. Following this recommendation during initial first aid, both lay and professional, would likely save lives. The patient should be kept in this position or fitted with antishock trousers during transport into ambulance and in hospital until the blood pressure has recovered spontaneously or responded to epinephrine, volume replacement, or other appropriate measures. There is evidence in a canine model,[8] in a human in vitro model,[9] and in clinical practice[10] that epinephrine might not be able to reverse established anaphylactic shock, so care should still be taken to prevent the adverse effects of posture while a partially treated patient is being moved.

Whatever the mechanism for these deaths, there seems sufficient evidence from the observations to suggest that these postural instructions should be incorporated into both basic and advanced life support training. Patients thought to be at risk of anaphylaxis and those who might become involved in their care (teachers, babysitters, spouses, friends, and coworkers) should be told of their need to remain lying down if they feel faint during a reaction, unless there is a greater need to sit up to overcome difficulty in breathing. The events during the nonfatal wasp sting reaction reported here suggest that those with epinephrine should be instructed to remain supine rather than sit up to use their autoinjectors if they feel faint.

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doi:10.1067/mai.2003.1614

## Allergy to ingested mycoprotein in a patient with mold spore inhalant allergy

*To the Editor:*

We would like to present a case of severe anaphylactic-type allergic reaction after the first ingestion of a Quorn product.

A range of fungus-derived meat alternative products (Quorn) has been available in several countries in Europe and is now available in the United States. The major ingredient in these products is a mycoprotein made from the large-scale cell culture of the fungus *Fusarium venenatum*. It is obtained by continuous fermentation of this fungus in a tower to which oxygen, nitrogen, sugars, minerals, and vitamins have been added. The resulting paste of fungal mycelia is mixed with egg albumin as binder, flavored and colored as desired, processed to obtain sensory meatlike characteristics, and sold in the form of pieces, mince, burgers, fillets, or nuggets.[1]