Minutes July 17, 1998 **Lightning Data Center** Centura Health St. Anthony Central

Quote of the Month

"He would pick up the comic book and stack it with the other *Captain Marvels* on the top shelf of the metal cabinet...In the comic book..the faceless man..took Billy Batson to meet the ancient Egyptian wizard named Shazam...The white bearded wizard gave him the magic word that called down the lightning bolt. The lightning bolt that turned the boy into Captain Marvel, the world's mightiest man."

Pete Hamill ---*Snow in August*

1. Meeting began at 11:30 am and adjourned at 2:30 pm.

2. Members present: Cherington, Ciraldo, Clark, Collier, Cooper, Fischer, Foley, Glancy, Griebel, Hodge, Hodgson, Kamin, Kearns, Kithil, Kummerfeldt, Lammertse, Larson, McNelis, Parker, Reehl, Schuchardt, Shawo, Simmons, Rebecca Smith, Richard Smith, Swanson, Toler, H Wachtel, T Wachtel, E Ullrich, R Ullrich, Weissmann, Yarnell.

3. I distributed the following articles:

   a. Schmid RE. NASA: Lightning strikes are more frequent over dry land. *Boulder Daily Camera*. Saturday May 30, 1998.

   "The first 3 months of data from NASA's new satellite-mounted Lightning Imaging Sensor show a dramatic difference in the number of strikes between land and water areas...the satellite showed that 85% to 90% of strikes were over land, even though more than 70% of Earth is covered by water...The newly reported data cover December through February and show concentrations of lightning over Australia, Indonesia, sub-Saharan Africa, South America and the Caribbean area...It was winter in the Caribbean, and lightning often occurred there over water. In winter, the water tends to be warmer than the nearby land and so it generates convective storms."

   b. Still J, Orlet H, Law E, et al. Electrocution due to contact of industrial equipment with power lines. *Burns* 1997;23:573-5.

   The authors "report 7 cases. Two patients sustained cardiac arrest and were successfully at the scene. Four patients lost consciousness and in two cases, amnesia for the event was encountered...Surgery including amputation was sometimes required...These industrial accidents plainly indicate the risk of injuries from contact of conductive metal equipment with power lines. The injured worker was standing on the ground in each of our cases."

   c. Cherington M, Wachtel H, Yarnell PR. Could lightning injury be magnetically induced? *The Lancet* 1998;351:1788.

   This article is attached to the minutes. Howard Wachtel discussed the article briefly. Mary Ann Cooper suggested that over 30% of lightning casualties may have no obvious skin lesions.

4. Don Schuchardt raised the questions of sailboat safety and the value of lightning rods on boats. Rich Kithil stated that some recommend the use of automobile cables be attached to metal items on the boat and then to the ground plate.

5. George Hodge reported about a recent case of a motorcyclist who suffered a lightning strike to his helmet. The current traveled through his hands. He survived. George also reported that so far this summer there have been 80 forest fires set by lightning each day in Canada.

6. Bob Glancy brought a poster from the National Geographic Society Magazine (May 1998) that showed maps and the locations of Great Disasters.

7. Carl Swanson reported that lightning struck a nearby tree and then damaged part of the Natural History Museum one week ago. He asked if anyone in the group might have suggestions regarding repairs and future safety considerations. (LDC, of course, does not provide such service). Ron Larson said he would visit the site with Carl. Carl said he would bring pictures of the lightning damaged areas to the next meeting.

   Carl also brought a photo that he had taken of evening lightning and asked the group to identify two bright images on the picture. Howard suggested that the linear images might have originated in clouds near the lightning flash. I suggested that Carl is to be commended for his contribution to what has become a regular addition to our monthly meeting: His bringing a photo of some unknown image and ask the group to identify it.

8. Michael Foley and Warren Simmons each brought copies of recent articles from the newspapers on lightning matters. Warren brought an article by M. Arkush entitled A Shocking Memory from *Golf World* (July 3, 1998) that give details of the 1975 Western Open near Chicago where three professional golfers (Heard, Trevino, and Nichols) were hit by lightning.

9. Cheryl Toler reminded the group of our new fax number and email address:

   LDC email address: lightningdatacenter@centura. org
   LDC new fax number: 595 6217
   LDC phone number: 629 4258

10. The Main Event of this meeting were 2 wonderful presentations by Dr. Mary Ann Cooper of the University of Illinois at Chicago. First, she spoke about Lightning Safety Group Recommendations that were produced by the LSG (Lightning Safety Group) that met in January 1998 in Phoenix, Arizona. Then, she spoke about the animal research that she and her colleagues are performing in Chicago. I would not do justice to her talks by trying to summarize them here. The recommendations of LSG can be found on her Web site. I shall just describe some of the discussion that followed her formal presentations.

    Bob Glancy, and others, raised the problem that people may fail to follow recommendations, if they are so conservative and there are many "false alarms." Many of us in LDC have discussed this "boy who cried wolf" phenomenon in the past, with regard to lightning safety recommendations. Mary Ann acknowledged that this is a problem but LSG has chosen to take a conservative position. She indicated that the recommendations may change with time and new information.

    Howard Wachtel asked about the recommended "baseball catcher positions with

head down and covered ears" when one is caught in an open field during lightning strikes. Mary Ann stated that LSG did not take up this matter. She indicated that in several areas of lightning safety, recommendations are often based on "common sense" when there may be no scientific data. Michael Foley stated that the phenomenon of 'step-voltage' would provide rationale for placing one's feet together. The idea of covering one's ears was first suggested here by Carl Swanson. It was the consensus of the member present, that if one were in the unfortunate situation of being caught in an open field with no shelter during an lightning strike, that the "baseball catcher" position is preferable to standing or lying down.

After the meeting, several of the members present congregated at a downtown Denver outdoor cafe for dinner. A fine ending to one of our most enjoyable and informative meetings.

11. These minutes reflect to comments of the members present and do not reflect any stated positions of the LDC.

12. Next meeting: Friday August 14, 1998 at 11:30 am in the Main Auditorium of St. Anthony Central Hospital

Respectfully submitted,

M. C.

Michael Cherington, MD
Chair, Scientific Committee, LDC

age of onset or *APOE* status, and to estimate odds ratios adjusted for age and sex.

The genotype and allele distributions were similar to that described by Kang and colleagues[4] (table). The *LRP* CC genotype was over-represented in AD (odds ratio 1·5, [95% CI 1·2–2·0], p=0·002) compared with controls. Although no statistical interaction could be detected between *LRP* polymorphism and age at onset, the association of the *LRP* CC genotype was more pronounced in late-onset AD cases (1·7 [1·2–2·3], p=0·001, age at onset >65 years) than in cases with earlier ages at onset (1·2 [0·7–1·9], p=0·520, age at onset ≤65 years). Similarly, the level of association between the *LRP* CC genotype and AD tended to be stronger in those carrying at least one ε4 allele (2·2 [1·3–3·7], p=0·006), than in people without an ε4 allele (1·5 [1·0–2·3], p-0·080), despite the lack of significance of the statistical interaction.

Kang and colleagues[4] reported that the *LRP* CC genotype was a risk factor for familial late-onset AD and described a similar trend in sporadic late-onset AD cases, lack of significance in this latter group probably being due to the small sample size. Our results extend the possible effect of the *LRP* CC genotype to sporadic late-onset AD cases. However, we cannot reject the hypothesis that linkage disequlibrium exists between this *LRP* polymorphism and another polymorphism within *LRP* or neighbouring genes. In the light of linkage data implicating a new locus on chromosome 12 for late-onset AD,[5] the genetic association of *LRP* variability with both familial and sporadic late-onset AD may confirm involvement of the *LRP* locus in the disease.

We thank Jordi Pérez-Tur for his helpful discussion. J-CL is a recipient of the Ministère de l'Enseignement Supérieur et de la Recherche. This work was supported by the Institut National pour la Santé et la Recherche Médicale, the Institut Pasteur de Lille, the Conseil Régional du Nord-Pas de Calais 'axe régional de recherche sur les maladies neurodégénératives et le vieillissement cérébral' and the Fondation pour la Recherche Médicale.

1 Lendon CL, Talbot CJ, Craddock NJ, et al. Genetic association studies between dementia of Alzheimer's type and the three receptors for apolipoprotein E in Caucasian population. *Neurosci Lett* 1997; 222: 187–90.

2 Wavrant-De Vrièze F, Pérez-Tur J, Lambert J-C, et al. Association between the low-density lipoprotein receptor-related protein (LRP) gene and Alzheimer's disease. *Neurosci Lett* 1997; 227: 68–70.

3 Clatworthy AE, Gomez-Isla T, Rebeck GW, Wallace RB, Hyman BT. Lack of association of a polymorphism in the low-density lipoprotein receptor-related protein gene with Alzheimer disease. *Arch Neurol* 1997; 54: 1289–92.

4 Kang DE, Saitoh T, Chen X, et al. Genetic association of the low-density lipoprotein receptor-related protein gene (LRP), an apolipoprotein E receptor with late-onset Alzheimer's disease. *Neurology* 1997; 49: 56–61.

5 Pericak-Vance MA, Bass MP, Yamaoka LH, et al. Complete genomic screen in late-onset familial Alzheimer disease. *JAMA* 1997; 278: 1237–41.

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Could lightning injury be magnetically induced?

Michael Cherington, Howard Wachtel, Philip R Yarnell

Lightning injuries are usually thought to be caused by direct strike, side flash, or ground current;[1,2] none of which explain lightning-related deaths where current does not apparently enter or leave the patient's body.

In June, 1996, a 32-year-old man and three other golfers stood under a tree during a lightning storm. When lightning struck the tree, the patient suffered a cardiac arrest. Cardiopulmonary resuscitation was given by a physician who was nearby. The patient was taken to hospital but remained comatose and died on the 18th day. Three other golfers under the same tree survived. One had surface burns on his head, neck, and abdomen at places where he wore metal objects: necklace, belt buckle, and metal button on a cap. The other two golfers had only brief loss of consciousness. This case and at least four other cases in the medical literature[3] are unusual in that patients succumbed to lightning but there was no evidence of external damage from lightning currents. Lightning-related hypoxic encephalopathy secondary to cardiac arrest is often fatal.[3] Most lightning casualties have external signs of damage from contact with electrical current, such as skin burns and Lichtenberg figures or "ferning".[4,5] However, some patients have a cardiac arrest as the result of a lightning strike without external signs of electrical burns.

Lightning "bolts" have very high peak currents (≥100 000 amps) which rise in μs and decay more slowly. They may produce intense nearby magnetic fields (several millitesla at a distance of about 1 m), which may induce large but short-lived (<1 ms) currents in a human body. The induced current wave-form is proportional to the change per time of the magnetic field. The lightning may induce a loop current within the human torso without evidence of current entering the body. If these currents occur during a vulnerable part of the cardiac cycle, they could cause asystole or ventricular fibrillation.*

This hypothesis may be tested on mice or rats exposed to rapidly rising magnetic field pulses that approximate the dynamics of lightning currents within cylindrical chambers enclosed by solenoid windings. This method would necessitate the use of fields on the order or ten times as great as the natural lightning fields. Our proposed mechanism may explain some unwitnessed and unexplained "heart attacks" among hikers found dead in the mountains.

Presented in part at the American Association of Physics Teachers Meeting in Denver, Colorado, August 14, 1997.

We thank Vincent W Vanek.

*Lightning stroke with peak current 100 000 amp gives peak magnetic field (B_p):

$$B_p=\frac{\mu_o I_p}{2\pi R}$$

Where μ_o=magnetic permeability of air $4\pi(10^{-7})$ Webers/A•m I_p=peak current (amps). R=distance from the lightning stoke (m).
For a distance of 1·0 m, $B_p=2(10^{-2})$ Tesla. Lightning current rises to its peak in about 10^{-6} s, so the rate of rise of dB/dt is $2(10^4)$ Tesla/s. Electrical field induced in a cylindrical object (human torso)

$$E=\left(\frac{a}{2}\right)\frac{dB}{dt}$$

Where E=electrical field (v/m) a=radius of the induced current path (m). Highest fields would be at the perimeter of the torso and the lowest ones produced in the centre. With an estimate of a=0·1 m yields E of about 1000 V/m for dB/dt=$2(10^4)$ Tesla, and current density of about 1000 A/m² through the ventricles (tissue resistivity 1 ohm/m). Long current pulses (of ms) or for 60 Hz, such a current density would lead to arrhythmias. For current pulses lasting a few μs, electrical impedance of cardiac-cell membranes is due almost entirely to the membrane capacitance (Cm) which is on the order of 0·01 F/m², the change in membrane potential (ΔVm) is

$$\Delta Vm=\frac{J(\Delta t)}{Cm}$$

For J=1000 A/m², and the duration of the current pulse, $\Delta t=10^{-6}$ s, predicts a ΔVm of 100 mV. If the cardiac cell is in a refractory state this current is not likely to re-trigger a discharge in the active phase corresponding to the ECG T wave. Ventricular fibrillation or asystole may result.

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2 Cooper MA. Emergent care of lightning and electrical injuries. *Semin Neurol* 1995; 15: 268–78.

3 Wetli CV. Keraunopathology: an analysis of 45 fatalities. *Am J Forens Med Path* 1996; 17: 89–98.

4 Cherington M, Yarnell PR, London SF. Neurological complications of lightning injuries. *West J Med* 1995; 162: 413–17.

5 ten Dius HJ, Klasen HJ, Nijsten MWN, Pietronero L. Superficial lightning injuries: their "fractal" shape and origin. *Burns* 1987; 13: 141–46.

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