CASE REPORT

Impact of Lightning Strikes on Hospital Functions

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Abbreviations:
ICT = Information and Communication Technologies

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Abstract
Two regional hospitals were struck by lightning during a one-month period. The first hospital, which had 236 beds, suffered a direct strike to the building. This resulted in a direct spread of the power peak and temporary failure of the standard power supply. The principle problems, after restoring standard power supply, were with the fire alarm system and peripheral network connections in the digital radiology systems. No direct impact on the hardware could be found. Restarting the servers resolved all problems. The second hospital, which had 436 beds, had a lightning strike on the premises and mainly experienced problems due to induction. All affected installations had a cable connection from outside in one way or another. The power supplies never were endangered. The main problem was the failure of different communication systems (telephone, radio, intercom, fire alarm system). Also, the electronic entrance control went out. During the days after the lightening strike, multiple software problems became apparent, as well as failures of the network connections controlling the technical support systems. There are very few ways to prepare for induction problems. The use of fiber-optic networks can limit damage. To the knowledge of the authors, these are the first cases of lightning striking hospitals in medical literature.

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Introduction

Lightning has fascinated man throughout history. It was the first source of fire during prehistoric times and was seen to have mythical, even divine properties later on.[1] Although there are multiple case reports on lightning-induced lesions,[2,3] no other medical literature on the impact a lightning strike has on a hospitals ability to function was identified. A Google search yielded anecdotal descriptions of power outages secondary to external supply problems[4,5] and one Indian newspaper article on a compound that was struck by lightning.6 Nevertheless, a hospital that gets struck by lightning can have serious problems with several aspects of daily operations. Two cases of hospitals that were struck by lightning, and the problems that followed are provided.

Cases

Two regional hospitals were struck by lightning during a one month period.

Case 1—The first hospital, which had 236 beds, suffered a direct strike to the building. This resulted in a direct spread of the power peak and temporary failure of the standard power supply. The principle problems, after restoring the standard power supply, were with the fire alarm system and peripheral network connections in the digital radiology systems. No direct impact on the hardware could be found. Restarting the servers resolved all of the problems.

Case 2—A few weeks later, the second hospital, which had 436 beds, had a lightning strike on the premises during a thunderstorm, causing problems due to induction. All affected installations had a copper (co-ax) cable connection from outside in one way or another. The power supplies were not damaged. The surveillance cameras and the entrance control system (badge readers) went out of order, as did the fire alarm system. The patient attendance system and the "code blue" resuscitation alarm buttons in the wards ceased to function. The CO monitoring system in the underground parking lot was disrupted, as was the modem that monitors the main oxygen tanks. The main problem was the failure of different communication systems. One of the two radios used for prehospital communication went out, although both radios were connected to the same antenna post and amplifier. A number of analogue telephone lines ceased functioning, but the digital lines remained functional. The public address system, the in-hospital radio, and the entrance and parking intercoms ceased functioning. Another major problem was with software. Shortly after the impact, problems with the hospital administration system occurred, so no new patients could be introduced. Electronic patient files were unavailable and the automated medication dispenser ceased functioning. These problems were solved by restarting the servers. Afterwards, there still were problems with the digital telephone center and failures of the network connections controlling technical support systems became apparent. There were no physical damages to patients or personnel. No local damage from the direct impact on the compound was found. Total costs of the lightning strike were estimated >50,000 Euros.

Damage assessments in both hospitals were done by their technical support teams, as well as by their information and communication technology (ICT) specialists. The assessments were done immediately after the first problems were encountered. After inventorying the problems, a triage was done to set priorities for intervention. External contacts (suppliers, producers, and maintenance teams) were mobilized and emergency scenarios (e.g., continuous opening of disrupted gates and doors) were activated. Repairs of non-vital structures took up to two months to complete.

Discussion

A joint debriefing lead to the conclusion that we are rather powerless when confronted with lightning strikes. Available protective resources are limited, very expensive (especially in low risk areas), and cannot offer any guarantee regarding damage control (see discussion). Business continuity planning is mainly focused on the organizational level, including back-up scenarios and well-prepared contacts/contracts with suppliers, producers, and maintenance teams.

Structural damage to buildings, be it a hospital or any other structure, can be direct or indirect.[7] The direct impact of a bolt of lightning can rip through roofs, explode walls of brick and concrete, or cause fires by igniting combustible materials. The lightning current can be carried directly into and through the building by power and/or data lines, as well as through all conductive materials. This causes serious damage to electrical equipment, especially electronic circuits. Indirect damage is the result of induction. The huge electromagnetic fields from a lightning strike induce voltage and currents through conductors (wires and cables) inside of a building. Although these surge currents are less intense than in direct strike, they are quite capable of damaging integrated circuits in computers and other electronic equipment. The stability of software applications, even with intact hardware, is very vulnerable to peak currents. Hospitals have become high tech institutions, depending on ICT and electronics for diagnosis, treatment, and many aspects of their daily operations, making them extremely vulnerable, even to the indirect effects of a lightning strike. Apart from the physical damage, there also is a financial loss due to the extended suspension of normal activities. An impact also can directly cause injury or death to patients and personnel, not only from explosions or fires, but also from side flashes from plumbing fixtures, telephones, and other appliances attached to the outside through conductors.[1,8] The greatest risk in hospitals is posed by secondary damage due to malfunction of monitoring or vital support systems. Unforeseen interruption of critical interventions, as well as insufficient alarm systems, can cause serious problems.

As with other events due to natural hazards, it is difficult to prepare for a lightning impact. Lightning rods can be used to divert a direct hit. However, even with a lightning rod, up to 50% of the current will be spread over different conductive elements in the building. These major energy transfers create an induction problem on their own, so the lightning rod offers a false idea of security.[9]

Protection against induction is even more difficult. Theoretically, a Farraday's cage could isolate a building from external energy transfers. However, in real life, this is not feasible. Apart from the costs of such a project, the building remains dependent on cabling for power input. It also would be illegal according to European guidelines that state that there should be no potential differences over outlining walls of a building.[10] While planning new hospitals, one could use multiple groundings with an equal resistance, simulating a Farraday's effect.[11] A hospital's energy supply is ideally provided by an underground cable network, reducing the risk for a direct impact. Grounded protection of the cable will reduce the effects of induction. A high voltage break system can switch off your installations in a millisecond, which in turn can cause damage to critical functions; use of an uninterruptible power supply unit can cope with this. Furthermore, there is no break system that always can prevent all energy transfer, certainly not in case of a direct impact. All communication lines in and out of the hospital should use fiberglass cabling, to prevent surge transfer. Wireless technology can help in data transmission, but is more vulnerable to induction problems. In a hospital, electrical lines are required for power transfer to all equipment. In the case of existing hospitals, the costs will limit the use of all preventive measures described above. A good inventory of all connections from outside the building or between separate buildings is mandatory. All unused cables and pipes (also water and heating) should be omitted. The grounding of all persistent conductors should be checked, and all conductors should be placed on the same potential level toward the grounding. Surge protective devices can protect power cabling. Wherever possible, fiberglass optic and wireless techniques should be applied. As always, a risk benefit calculation will guide investments. In planning, good appointments with suppliers, producers, and maintenance teams are priceless.

Conclusions

Lightning can have a serious impact on a hospital's ability to function. There are limited possibilities for protective measures.

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