Background

During defibrillation, most therapeutic current travels through the patient's torso along the least resistive path between one electrode and the other. Some of the current will travel along the patient's skin. If the patient is on a dry nonconductive surface, no current will flow outside of the patient and thus all the energy is delivered to the patient. In this case, there is no risk of an electrical shock to the rescuer or bystanders so long as no one touches the patient during the discharge of energy. However, if the patient is on a somewhat conductive surface, such as a wet surface, some of the discharged energy may travel outside the patient's body as it flows from one electrode to the other. This situation has created some concerns about electrical shock hazards to rescuers or bystanders during the defibrillation of patients.

Patients have been historically defibrillated on both conductive (e.g., metal floor of a helicopter) and non-conductive (e.g., dry wood floor) surfaces without posing harm to rescuers or bystanders so long as no one touches the patient during energy discharge. According to the American Heart Association (Guidelines 2000), metal surfaces "pose no shock hazard to either victim or rescuer". In the case of water, the American Heart Association (Guidelines 2000), recommend removing the victim from freestanding water and drying the victim's chest before using the AED.

The purpose of this test was to measure transient voltages that a rescuer or bystander would be exposed to if the Zoll AED Plus was used on a wet surface. For the purposes of this test, it was assumed that the rescuer or bystander would be standing or kneeling on a wet concrete surface with bare feet, knees, or palms in contact with the wet surface. Based on Ohm's law, the amount of current that will flow through a bystander during defibrillation is proportional to the voltage measured between different parts of the rescuer's body touching the wet surface.

Procedure

Refer to Figure 1 Test Procedure Diagram. A 21 pound thawed turkey (used to emulate a human body) was placed in the middle of a 7.5'x7.5' concrete surface. The surface was marked off in 18"x18" grids with masking tape. A five gallon bucket of chlorinated pool water was poured on the turkey and test surface to simulate a wet environment. An AED Plus was placed next to the turkey and attached across the breast with a set of Zoll Stat Padz II. The AED Plus was placed in diagnostic mode and manually charged to full energy (200J) and discharged under control of a laptop computer running Zoll Administration Software (ZAS). More pool water was poured on the turkey and test surface as needed to keep the surface wet.

Refer to Figure 2 Sense Probe. A sense probe was used to simulate a rescuer or bystander with bare feet, knees, or palms in contact with the concrete surface. Impedance measurements were made by standing, kneeling, and leaning palms first on a set of Stat Padz II connected to an LCR meter. The three measurements were all approximately 1k Ohm. The sense probe was constructed of two 3.2" diameter metal plates connected by a 1k Ohm resistor. The metal plates were taken from an Impulse 4000 defib analyzer. The voltage across the sense probe was monitored and plotted with an oscilloscope after every 200J discharge. The sense probe was placed in the center of every grid in both the horizontal and vertical position. The AED Plus was also discharged with one plate on the treatment button and one plate on each of the 3 grids surrounding the AED Plus to simulate a rescuer pressing the treatment button while in contact with the wet concrete surface.

The concrete surface was rinsed off and the test was repeated with sea water. Pictures were taken of the test area, refer to figure 3.

Figure 1. Test Procedure Diagram

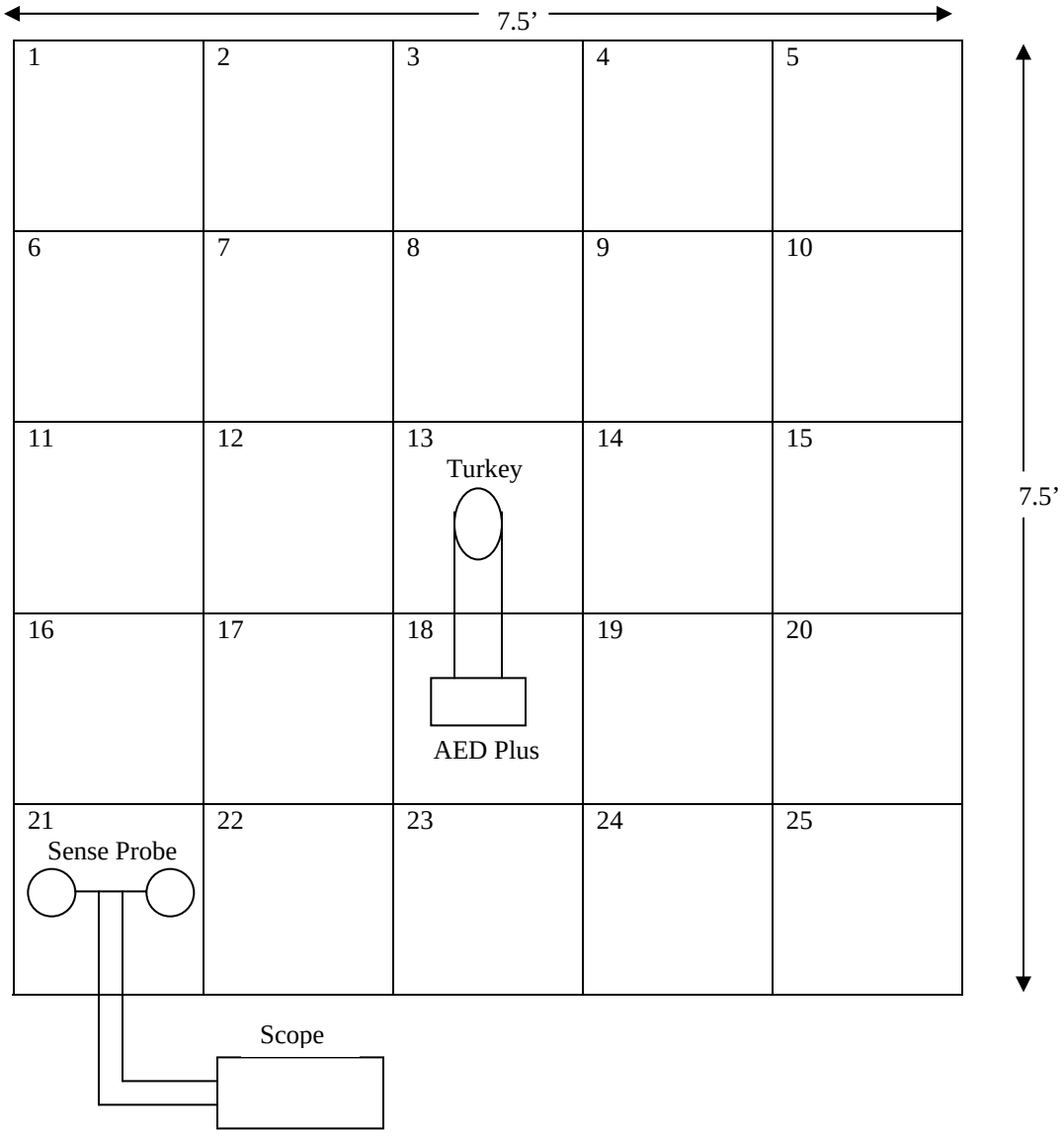

Figure 2. Sense Probe

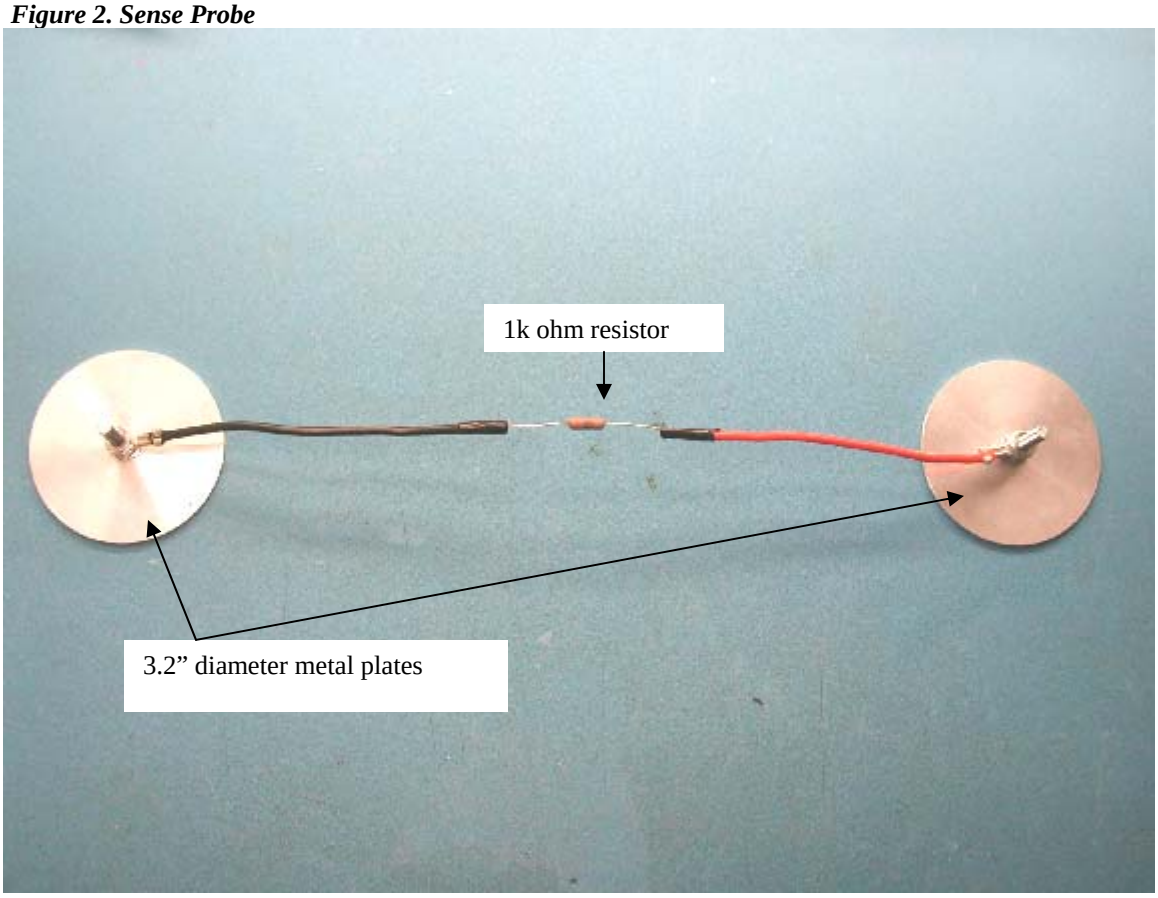

Figure 3. Test Area

Results

The following tables show the highest recorded voltage that was measured in each grid square. The grid number is in the upper left corner. The voltage between the two metal plates was measured with the plates in the horizontal and vertical positions. The recorded voltage is the highest of the horizontal and vertical position voltages.

Table 1. Pool Water Results

1 0.0Vp	2 0.0Vp	3 0.0Vp	4 0.0Vp	5 0.0Vp
6 0.0Vp	7 0.0Vp	8 0.10Vp	9 0.04Vp	10 0.0Vp
11 0.0Vp	12 0.06Vp	13 Turkey	14 0.12Vp	15 0.0Vp
16 0.0Vp	17 0.0Vp	18 AED Plus 0.07Vp	19 0.03Vp	20 0.0Vp
21 0.0Vp	22 0.0Vp	23 0.0Vp	24 0.0Vp	25 0.0Vp

Table 2. Sea Water Results

1 0.0Vp	2 0.07Vp	3 0.34Vp	4 0.15Vp	5 0.14Vp
6 0.10Vp	7 0.22Vp	8 3.0Vp	9 0.68Vp	10 0.90Vp
11 0.0Vp	12 0.46Vp	13 Turkey	14 0.75Vp	15 0.24Vp
16 0.06Vp	17 0.24Vp	18 AED Plus 0.44Vp	19 0.36Vp	20 0.0Vp
21 0.0Vp	22 0.04Vp	23 0.06Vp	24 0.04Vp	25 0.0Vp

Conclusion

A maximum of 3.0 volts was recorded in sea water at the grid square (# 8) above the simulated patient, a maximum of 0.12 V was recorded in chlorinated pool water (grid # 14), and a maximum of 0.03 volts was recorded from the shock button to the wet concrete surface. It is unlikely that these voltages would cause a risk or be considered hazardous to a rescuer or bystander since they are, in the worst case, substantially less than those produced by a standard 9 V transistor radio battery. The results of this experiment show that a rescuer or bystander would not be exposed to any hazardous voltages if a patient was defibrillated on a wet surface as long as the appropriate safety precautions are taken. Specifically, no one touches the patient during the energy discharge when the shock button is pressed. The AED Plus is designed for ease of use and to provide a clear set of voice and text prompts to ensure the appropriate use of the device. When the AED Plus is analyzing a patient's rhythm the "Don't Touch Patient Analyzing" prompt is displayed on the LCD and reinforced by a voice prompt. Also, when the rhythm is determined to be shockable and AED Plus is fully charged, the "Don't Touch Patient, Press Shock Button" is displayed on the LCD and reinforced by a voice prompt. All these prompts are designed to assist in rescuing the patient according to the AHA Guidelines and to make the device safe and easy to use.