Lithotripsy in a Patient with an Automatic Implantable Cardioverter Defibrillator

AUDREY L. LONG, M.D.,* FERDINAND J. VENDITTI, JR., M.D.†

The automatic implantable cardioverter defibrillator (AICD) is a device that senses ventricular tachycardia and ventricular fibrillation and responds with countershocks to the heart. Extracorporeal shock wave lithotripsy (ESWL) is a noninvasive method of dissolution of calculi using shock waves. It requires anesthesia, or at least analgesia, and monitoring by an anesthesiologist. In a patient with an AICD device undergoing ESWL, there is a possibility of shock wave damage to the AICD generator. We report the preparation and management of a patient with an AICD for ESWL of a right renal calculus.

CASE REPORT

The patient was a 72-yr-old man with coronary artery disease and acute renal failure secondary to right nephrolithiasis and a nonfunctioning left kidney. He had been admitted to another hospital with congestive heart failure (presumably secondary to fluid overload from renal failure) and required tracheal intubation. His hospital course was complicated by refractory ventricular tachycardia for which he underwent implantation of an AICD (Ventak 1550, Cardiac Pacemakers, St. Paul, MN). Medications included nifedipine, labetalol, furosemide, albuterol, and propafenone. Congestive heart failure and renal failure improved with hemodialysis and placement of a ureteral stent. He was transferred to the Lahey Clinic Medical Center for ESWL of the right renal calculus 2 months after AICD implantation.

The cachectic man was 178 cm tall, weighed 75 kg, and had clear lung fields. Electrocardiography showed sinus rhythm with first-degree atrioventricular block, nonspecific ST–T changes, and intraventricular conduction delay. His arterial oxygen tension (Pa_{O_2}) was 88 mmHg while he was breathing oxygen 2 l/min by nasal cannula. Results of coagulation studies were within normal limits. The serum creatinine concentration was 2.6 mg/dl.

Because no information was available about the effect of shock wave on the AICD generator, we performed a preparatory experiment before treating this patient's calculus with ESWL. Because of its high replacement cost and the potential for patient morbidity, we needed to determine whether the pulse generator would be damaged by electromechanical interference.

An AICD generator was taped to another patient undergoing right renal ESWL. The device was secured to the left abdominal wall (at the

location of usual implantation) with 3-inch foam tape. A 1-inch thick 10 × 6-inch Styrofoam board was taped to the patient's left flank to protect the device from unfocused shock waves. The patient received 2,400 shocks to the right renal calculus. Halfway through and at the completion of treatment, the integrity of the AICD was checked by the cardiologist with a hand-held programmer (Ventak model 2035 Universal Programmer, Cardiac Pacemaker) and was found to be intact. The device was then sent to the manufacturer for bench analysis, which disclosed no detectable damage.

With favorable results of the trial run and bench analysis, it was decided to proceed with ESWL of our patient's right renal calculus. Preoperative preparation included insertion of radial artery and pulmonary artery catheters. The patient's initial blood pressure was 160/60 mmHg, heart rate was 70 beats per min, and pulmonary arterial pressure was 39/18 mmHg. A lumbar epidural catheter was inserted, and 15 ml of 2% plain mepivacaine was injected incrementally to achieve a T3 sensory level, and the patient was transferred to the lithotripsy suite. The AICD was then deactivated by the cardiologist with the hand-held programmer, and the Styrofoam board was taped to the patient's left flank. The patient was immersed in the Dornier HM3 Lithotripter (Dornier Medical Systems, Inc., Marietta, GA) to approximately the T8 level. Hemodynamics remained unchanged with immersion. He received 1,800 shocks to the right renal calculus with good stone fragmentation. During the procedure, he exhibited occasional short bursts of supraventricular tachycardia requiring no treatment but was otherwise stable. He was removed from the tub; the AICD was reprogrammed; and he was transferred to the regular nursing floor that evening.

The following day the device demonstrated appropriate sensing and firing.

DISCUSSION

The AICD (Ventak 1550) consists of a pulse generator implanted in the left abdominal wall connected to electrodes implanted on the surface of the heart. The unit senses ventricular tachycardia and ventricular fibrillation and delivers up to five countershocks of 30 joules each. The device may be externally programmed to an active or inactive mode by a hand-held programmer or magnet. In addition, the hand-held programmer may initiate defibrillation by the device. Electromagnetic interference has been known to inhibit as well as cause inappropriate firing of the pulse generator, and therefore the device usually is deactivated before elective surgery when electrocautery will be used.‡ The patient's electrocardiogram

---

---

‡ Deutsch N, Hantler CB, Morady F, Kirsh M: Perioperative management of the patient undergoing automatic internal cardioverter-defibrillator implantation. Journal of Cardiothoracic Anesthesia 4:236–244, 1990

is continuously monitored, and external defibrillation is performed, if necessary, without harming the device.§

ESWL (Dornier HM3) uses an electromechanical shock wave generated by an 18–24-kV discharge between spark plug electrodes, resulting in an explosive water evaporation and expanding bubble creating a propagated shock wave. An ellipsoid reflector focuses the wave at a second focal point (F2), 2 cm in diameter. When the wave traverses areas with differing acoustic impedance, energy is dissipated. The shock wave is synchronized to occur 20 ms after the R wave of the electrocardiogram.¶

Because ESWL involves an electromechanical discharge that could possibly interfere with the AICD pulse generator, we planned to turn the device off before ESWL. External defibrillation would have been possible with the hand-held programmer covered by a plastic sleeve while the patient was still immersed or with a standard defibrillator out of the water. Our concern, therefore, was not that inappropriate firing or inhibition of the AICD would occur but that destruction of the piezoelectric crystal of the pulse generator might result. The precedent for this concern is found in the literature on pacemakers and ESWL. In simulation studies, Cooper et al.[1] found that two of four rate-responsive pacemakers (Activitrax, Medtronic, Minneapolis, MN) placed at F2 had their piezoelectric crystals shattered by the shock wave. Therefore, it was decided to attempt ESWL of our patient because the calculus was on the right side, where the pulse generator would not be in the direct path of the shock wave.

However, evidence exists that the shock wave spreads beyond the theoretical focused cone. Unfocused shock waves causing incidental fragmentation of a gallstone during right renal ESWL (located 5 cm from F2)[2] and

mild intestinal injury[3] have been reported. Arrhythmias are believed to be triggered secondary to mechanical stress on the myocardial conduction system.** It is for this reason that the shock wave is synchronized to occur during the refractory period of the heart. Therefore, we believed it prudent to protect the AICD from any possible unfocused shock wave damage. Styrofoam has been used to protect children's lungs from the path of the shock wave.†† It has many air solid interfaces that provide a higher acoustic impedance, and the wave is dissipated. Reston (3M), a foam sheet with adhesive backing, has been effective in one reported case†† and may have been as effective in our patient.

We have shown that a patient with an AICD can safely undergo ESWL of a right renal calculus. Additional investigation must be done to determine the safety of ESWL in a patient with an AICD and left renal calculus. Currently, surgical therapy is the only alternative.

** Cresteil-Simon A, Le Heuzey J-Y, Baras E, Deriaz H, Feder P, Tobelm G, Lienhart A: Cardiac arrhythmias during extracorporeal shock wave lithotripsy (ESWL) under epidural anesthesia (abstract). ANESTHESIOLOGY 65:A147, 1986

†† Tredrea CR, Pathak D, From RP, Grucza J. Lung protection in children during extracorporeal shock-wave lithotripsy (abstract). Anesth Analg 66:S178, 1987

---

§ Cardiac Pacemakers, Inc., St. Paul, MN: Personal communication.
¶ Malhotra V: Anesthetic care of patients for extracorporeal shock wave lithotripsy (ESWL). New York University Anesthesiology Comprehensive Review 9:406–426, 1989

REFERENCES

1. Cooper D, Wilkoff B, Masterson M, Castle L, Belco K, Simmons T, Morant V, Streem S, Maloney J: Effects of extracorporeal shock wave lithotripsy on cardiac pacemakers and its safety in patients with implanted cardiac pacemakers. PACE 11:1607–1616, 1988
2. Michaels EK, Fowler JE, Jr: Inadvertent fracture of gallstones during extracorporeal shock wave lithotripsy. J Urol 136:1285–1286, 1986
3. Al Karawi MA, Mohamed AR, el-Etaibi KE, Seed RF: Extracorporeal shock-wave lithotripsy (ESWL)-induced erosions in upper gastrointestinal tract: prospective study in 40 patients. Urology 30:224–227, 1987