



Ventricular tachycardia in patients subjected to extracorporeal lithotripsy

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Abstract

Five consecutive patients diagnosed with right renal lithiases, developed ventricular tachycardia during a non-synchronized extracorporeal wave lithotripsy, using an electromagnetic lithotripter. Although no patient had a past history of cardiac problems, ventricular extrasystoles were noticed at 300–500 wave impulses and the patients developed ventricular tachycardia at 2500–3000 impulses. The arrhythmia ended spontaneously when the lithotripsy was discontinued. Following replacement of the generator and head of the lithotripter, dysrhythmias of this nature were no longer a problem in 1200 subsequent patients. The possibility of interference between the shock wave and normal myocardial rhythm makes it essential to maintain proper upkeep of the lithotripter. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Extracorporeal shock wave lithotripsy (ESWL) is a safe technique for the treatment of urinary tract lithiasis. A radical change took place in the treatment of renal and ureteral lithiasis during the 1980s. The appearance of ESWL, whether associated with endourology or not, is the method of choice for the treatment of urinary lithiasis. Open surgery has been relegated to a marginal position in the treatment of lithiasis (nephrectomy for large calculi that result in a non-functioning kidney, correction of anatomic anomalies, large coralliform calculi, etc....), which are 1–2% of lithiases [1].

Complications may appear, however, while ESWL is being carried out. Although not significant in number, they include: hemorrhage, sepsis, cardiac arrhythmias and ‘steinstrasse’ (fragmented calculi that locate in the lower ureter and produce obstruction).

2. Clinical case studies

We present five patients who developed ventricular tachycardia during extracorporeal lithotripsy treatment with Siemens Lithostar Multiline. Standard preoperative evaluation included biochemistry, blood count and coagulation studies, chest X-ray and electrocardiogram (EKG), as well as discontinuation of anticoagulant or even platelet antiaggregatory drugs 1 week prior to procedure. Monitoring included EKG, pulse oximetry (SpO₂) and periodic checking of blood pressure during treatment. According to the protocol established at our hospital, analgesia was provided by a remifentanil continuous perfusion, 0.05 µg/kg per min ($n = 2$) or alfentanil at 20 µg/kg in bolus, followed 15–20 min later by another 8 µg/kg bolus ($n = 3$).

Five consecutive patients presented for right sided lithiasis (four with lower and one with an upper tract stone). None of the patients had a past history of heart disease. During the procedure isolated ventricular extrasystoles were observed in each of the five patients at 300–500 shock wave pulses (at 4 units of power); ventricular tachycardia developed (heart rate of 120 beats per min) that coincided with shock wave frequency. On discontinuing ESWL, arrhythmias ceased.

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Further procedures were suspended to permit checking by the lithotripter engineers. They found no fault whatsoever. At the insistence of the Anesthesiology and Resuscitation Department, which felt that there had to be a technical fault that was causing the arrhythmias, the generator, which had performed 6 million discharges (average life is 4 million), and the head, which has a mean life of 1 million discharges (2 million performed) were replaced. Once the replacement had been carried out, no rhythm disturbances took place again after the above-mentioned episodes.

3. Discussion

In 1966 an engineer from the Dornier company, by chance, discovered shock wave transmission when he experienced a type of electrical shock upon the impact of a projectile on a card with which he was in contact. The first report on the effects of shock waves was in the sixties and referred to tiny cracks in the structure of aircraft after impacting suddenly with drops of water and micrometeorites suspended in the atmosphere. The reaction is due to the release of energy when a high intensity force is generated at the interface between two media of different mechanical wave conduction capabilities. The waves are transmitted in a similar way in water and in human tissue (70% water), releasing part of their energy on reaching the interface with the surface of a stone [1]. The first publications on the use of this energy in the *in vitro* treatment of lithiasis appeared in 1971. Between 1974 and 1978 Chaussy conducted both *in vitro* and *in vivo* studies. The first experimental treatment on humans was carried out in 1980 [1].

Wave generation and focalization systems can be differentiated into two groups: (1) point source (electrohydraulic, LASER and microexpulsive); (2) wide source (electromagnetic and piezoelectric). In electrohydraulic systems both the patient and the wave generating electrode are immersed in the same bath filled with treated water. Shock waves, coordinated with the electrocardiogram, must originate during the refractory phase of the cardiac cycle, thereby avoiding myocardial stimulation and the generation of arrhythmias. This system continues to be a model in use at many hospitals [2].

Second generation lithotriptors are electromagnetic. The shock wave is transmitted to the patient via a silicone coupling diaphragm. Efficiency is enhanced by synchronizing discharges with respiratory movements. The technique requires a small focal point and constant precise locating; the wave enters the patient by way of a relatively large surface area. Patients need analgesia and/or surface sedation. At the present time, it is the form of energy used by most of the machines on the market.

Some studies have shown that cardiac arrhythmias are induced or exacerbated in 20–59% of patients by the use of piezoelectric and electrohydraulic lithotriptors. Arrhythmias occur in 1.4–9% of patients when electromagnetic lithotriptors are used without shock wave synchronization [5–8]. The dysrhythmias most commonly appearing are ventricular and atrial extrasystoles and bradycardia. These have been of no clinical significance.

There are various theories that attempt to explain the appearance of arrhythmias: (1) pre-existence of undiagnosed arrhythmias detected by continuous monitoring during lithotripsy [3]; (2) pain, anxiety or stimulation of the sympathetic system [3,4,6]; (3) vagal stimulation, giving rise to sinus bradycardia [3]; (4) positioning with decrease in venous return, or direct action of shock waves on the myocardium [4]; (5) pharmacological effects associated with sedation [3].

Zaneti et al. [9], when an electromagnetic lithotripter was used in patients who had not previously presented with arrhythmias, reported an 8.8% incidence of arrhythmia episodes with 5.6% being ventricular arrhythmias, but in no instance were they of clinical significance. The authors found no significant correlation between the appearance of an arrhythmia, the site treated, the number and strength of the shock waves or the administration of analgesics, but they did observe that arrhythmias occurred almost entirely in patients with kidney stones. Other authors have noted that cardiac extrasystoles may be caused by the direct effect of shock waves on the heart, especially during right kidney lithiasis therapy [6,10].

With piezoelectric lithotriptors, the arrhythmias most frequently detected were supraventricular, ventricular and atrial extrasystoles and bradycardia; one 13.5" cardiorespiratory arrest was observed [3]. In other studies [11], patients with previous cardiac disorders developed heart rates that were significantly faster prior to and following ESWL and also showed an increase of ventricular premature complexes. Billote et al. [12], reported the appearance of supraventricular tachycardia during ESWL when using an electrohydraulic lithotripter. They concluded that direct stimulation of the atrium with shock waves during an R wave was the causal mechanism.

Ounnoughene et al. [13], using Holter monitoring during treatment, evaluated the arrhythmogenic effects of desynchronized shock waves of the latest generation lithotriptors. In the synchronous mode no patient developed arrhythmias; in the desynchronized mode atrial and ventricular extrasystoles and an unsustained ventricular tachycardia were observed. These arrhythmias were asymptomatic and ceased spontaneously. The authors concluded, even though desynchronized procedures are arrhythmogenic, the risk with the latest lithotriptors may be acceptable if prior to the procedure

a cardiology examination is performed in an attempt to identify high-risk patients, and during the procedure these patients are monitored by an anesthesiologist.

Ventricular tachycardia occurring in our series of five patients was asymptomatic and disappeared when the procedure was discontinued. All patients were being treated for right renal calculi, the condition most frequently associated with the appearance of arrhythmias. We have found no publication describing this complication when using electromagnetic lithotriptors, although, as previously mentioned, this has been described for piezoelectric and electrohydraulic systems. Continuous monitoring of cardiac treatment is therefore advisable during treatment to permit early detection of cardiac disturbances, especially in patients with already diagnosed arrhythmias or severe heart disease. In patients with known arrhythmias, the option of EKG synchronization with the refractory phase of the cardiac cycle, although seldom used, may, in some cases, allow for a successful completion of the lithotripsy procedure.

In our institution, following replacement of the generator and head, no further episodes of ventricular tachycardia have occurred in approximately 1200 subsequent procedures. We conclude that these parts, used beyond manufacturer's recommendations, may have caused interference between the shock wave and myocardial fibre, with resultant arrhythmias.

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