Biliary Lithotripsy

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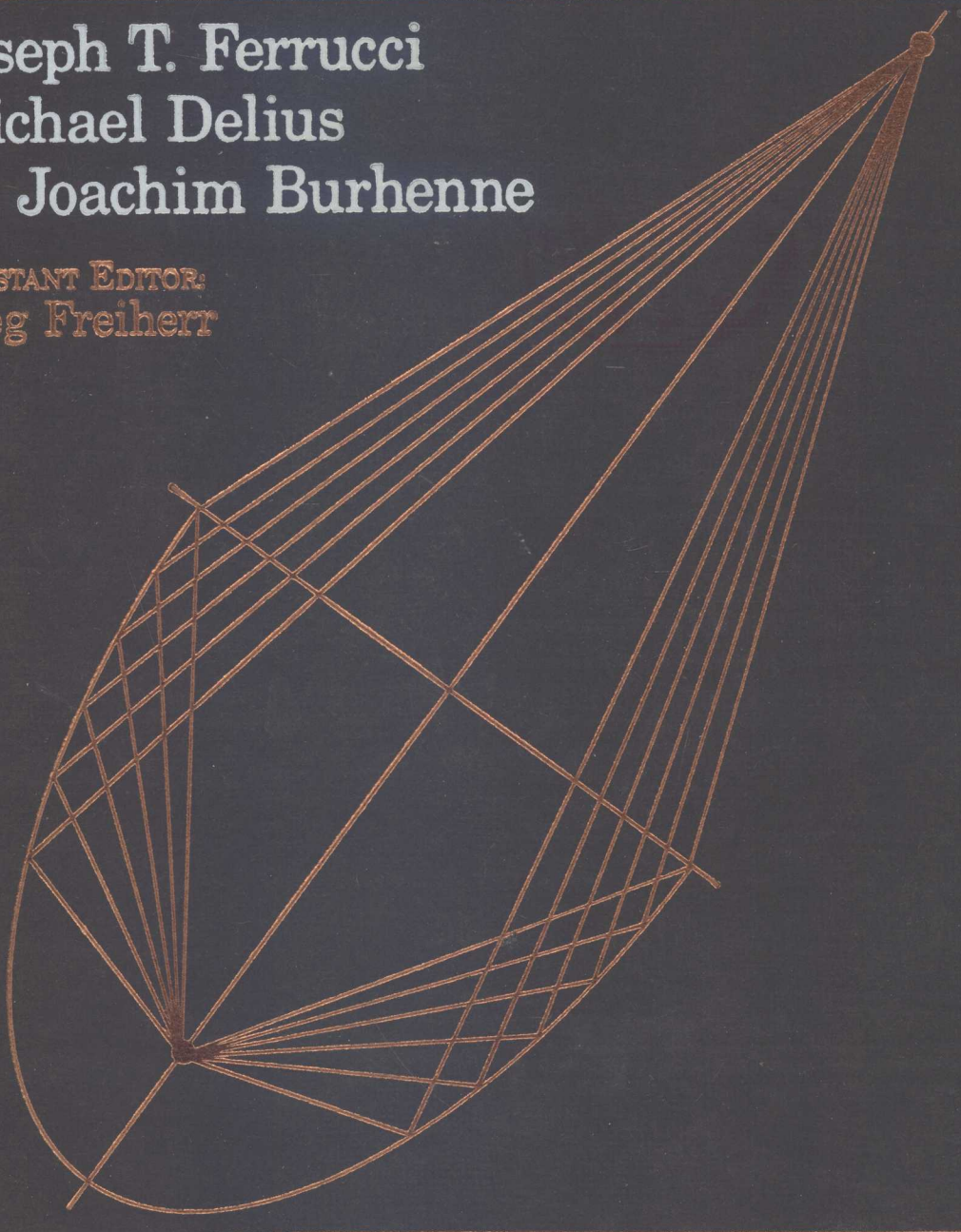

BILIARY LITHOTRIPSY

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Foreword

Biliary lithotripsy is a rapidly evolving new modality for nonsurgical treatment of gallstones. Only 3 years after the first treatment of a patient with a gallbladder stone by extracorporeal shock wave lithotripsy in 1985 at the Klinikum Grosshadern in Munich, the First International Symposium on Biliary Lithotripsy was called by Joseph T. Ferrucci. Its purpose was to bring together researchers, engineers, and clinicians from various disciplines pioneering and pursuing new therapeutic modalities for the nonsurgical treatment of cholelithiasis, be it extracorporeal shock wave lithotripsy itself or methods that are employed as adjuvant or complementary measures to this novel technique. The contributions to this symposium comprise this volume. They clearly show the interest and input that extracorporeal shock wave lithotripsy of gallstones is receiving from different specialists such as gastroenterologists, surgeons, and radiologists.

Obviously, the interdisciplinary approach will be very productive in the further development of this young but evolving new technology. Hopefully, it will not lead to new specialists, the lithotriptists, or a new discipline, knowing all about the shattering of stones but little about the disease and the patient. Thus, it is important not to overemphasize the single procedure, be it surgical, radiologic, endoscopic, or lithotriptic, but to approach the patient as a physician who is treating the patient and not only the stone. The better the technology is perfected and the better the interdisciplinary dialogue is cultivated, the easier it will be to attain this goal. It was impressive to see at this symposium how much one discipline had to offer the other and how the different manufacturers are striving to exceed each other in technical innovations. This development will continue and we shall see more of this in the future.

It can be concluded from the presentations and from the discussions of this symposium that for selected patients with cholelithiasis, extracorporeal shockwave lithotripsy is evolving as a safe and effective alternative to open abdominal surgery. At present, it should be restricted to symptomatic patients with radiolucent stones in a functioning gallbladder that are well suited for targeting and fragmentation. Since cholelithiasis is one of the most prevalent diseases, affecting approximately 10% of the adult population in the United States and in Europe, these results attract much attention. Caution, however, is prudent not to nourish hopes that are difficult to fullfill, such as to make open abdominal surgery obsolete. Even if the above requirements are fullfilled, cholecystectomy will remain the therapy of choice for patients with a pathologically altered gallbladder and for those with complicated disease.

Gustav Paumgartner, M.D.
Tilman Sauerbruch, M.D.

Preface

The convergence of several events in early 1988 have sparked a rapidly evolving transformation in the clinical management of gallstone disease, i.e., the emergence of safe, effective alternatives to cholecystectomy. First was the initiation of FDA approved clinical trials of gallstone lithotripsy by several lithotripter manufacturers. Second was the receipt of FDA approval to market the bile acid, ursodeoxycholic acid, an effective, nontoxic oral agent for dissolving cholesterol gallstones and presumably their fragments. Third was the publication in the *New England Journal of Medicine,* by German researchers from Munich, of highly favorable results with negligible complications in their first 175 gallstone lithotripsy patients. Fourth was the widening interest in the use of direct percutaneous contact dissolution of gallstones by the potent cholesterol solvent methyl tert-butyl-ether (MTBE). For the one in eight adults over 50 years of age in the civilized Western world who may harbor gallstones, these techniques alone or in various combinations promise as fundamental a change in therapy as the performance of the first cholecystectomy in Germany over 100 years ago.

This volume has been assembled in connection with the first worldwide meeting whose explicit focus is biliary lithotripsy, the technologic center of this new field of nonsurgical therapy of gallstone disease. The First International Symposium on Biliary Lithotripsy was held in early July of 1988 in Boston under the auspices of the Department of Radiology, Massachusetts General Hospital, and the Division of Continuing Medical Education of the Harvard Medical School. During the 3-day meeting, over 500 registrants received presentations from more than 30 invited speakers, heard 20 original proferred scientific papers, and viewed technical exhibits by nearly two dozen commercial firms.

The flavor of this symposium and of the entire field at this early stage has several different elements. These include the number and complexity of technical and clinical issues, the early dominance of European gastroenterologists and their interactions with the American commercial and medical communities, and the rivalry between different lithotripter manufacturers with vastly different shock wave systems and early clinical results. In combination, these elements are creating a rapidly expanding body of scientific knowledge and new professional relationships.

At the moment it is unclear whether the early European data will be reproducible in the United States and what the different commercial systems operating either alone or in combination with drugs will ultimately achieve. It is also uncertain how the highly competitive, rapidly evolving medical marketplace will influence dissemination of these technologies. As of this writing, only a few United States centers have clinical experience with any of these techniques.

It is fully recognized that the information exchanged in the symposium and presented within this volume will have a limited useful life. Nevertheless, in view of the intensity of interest among so many diverse parties, the challenge to transform the material into a permanent and hopefully useful volume was inescapable.

In order to produce a volume of timely interest, most of the material contained herein was obtained as finished manuscripts from the speak-

ers at the time of the meeting. In a few cases, edited transcript of verbal presentations are included and several additional manuscripts not presented at the time of the meeting have been obtained from distinguished members of the faculty to supplement basic research knowledge and newer clinical experience.

Finally, the senior editors wish to acknowledge the unique spirit of collegiality that has characterized the transatlantic dissemination of information from the initial European workers. The hospitality and patience with visitors, especially that shown by Professors Paumgartner and Sauerbruch to American physicians, has been remarkable. It is hoped that this international spirit will evolve and be reciprocated, at the very least, at subsequent multinational-multidisciplinary symposia now being planned.

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Editor's Note

The Greco-Latin derivation of the word *lithotripsy* is well known: lithos (stone) and tript (crush or fragment). The literature to date contains descriptions of both lithotrip*tors* and lithotrip*ters*, a source of some consternation to purists. We therefore consulted the Classics Departments of Harvard University and the University of British Columbia to obtain a concensus as to the preferred usage. *Lithotripter* shall refer to the machine. *Lithotriptor* shall refer to the operator. And. . . . for those who insist, *Lithotriptee* shall refer to the patient, *Lithotriptress* to female patients, etc. . . .

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Biliary Lithotripsy: What Will Be the Issues?

Joseph T. Ferrucci

The successful application of extracorporeal shock wave lithotripsy to cholesterol gallstones at the Groshadern Clinic, Munich, West Germany, in 1985 was the flashpoint of an unfolding revolution in the clinical management of gallstone patients.[1] Following the leadership of Dornier engineers, some 10 other firms are now testing various different lithotripter devices in Europe, the United States, and Japan. As of this writing, perhaps 1000 gallstone patients have undergone shockwave lithotripsy worldwide, and prestigious medical journals are gladly publishing the early results.[2]

As visible and dramatic as lithotripsy is, other competing and complementary therapeutic techniques are being introduced almost simultaneously to further accelerate the trend to nonsurgical management. These include both pharmacological and mechanical interventional methods. For example, direct contact dissolution of cholesterol gallstones by the potent solvent methyl tert-butyl ether (MTBE) has given highly successful results in early series.[3] Chemolysis of cholesterol gallstones using oral bile acids has had a long and successful clinical experience in Europe,[4–6] and the widely preferred agent ursodeoxycholic acid has recently been approved by the FDA for clinical use in the United States Various interventional techniques using direct mechanical basket or laser destructive techniques are also being widely applied under endoscopic and fluoroscopic guidance, especially for common bile duct stones. It is also highly likely that all these various techniques—lithotripsy, solvent dissolution, and mechanical intervention—can be used to advantage in a variety of yet unforeseen combinations.

It is therefore apparent that a new threshold of medical scientific knowledge is in view. For the one in ten adults worldwide who harbors cholesterol gallstones, a new range of therapeutic options is emerging, which ultimately promises to eclipse surgical cholecystectomy as the gold standard treatment of gallstone disease.

The field of nonsurgical management of gallstones is complex and, at present, somewhat immature. However, with the proliferation of equipment, metabolic information, and technical knowhow, new opportunities for research and scientific advancement are clear. A great deal of information has already been accumulated; and without minimizing the validity or importance of these data, it is likely that much of the information will prove to be preliminary and undergo refinement over the next several years. The major technical and clinical questions are becoming apparent, and some of the major issues that this Symposium will address are described below.

THE SHOCK WAVE: PHYSICAL PRINCIPLES

MECHANISMS OF SHOCK WAVE FORMATION

The Symposium will cover the *mechanisms of shock wave* formation and distinction of shock

waves from acoustic waves, the significance of the ability to focus shock waves, and the interrelation of the parameters affecting the focus (e.g., focal distance, aperture diameter, and focal zone size and shape). Mechanisms of transmission of shock waves in tissue and nature of energy deposition will also be discussed.

CHARACTERISTICS OF SHOCK WAVES

What are the pertinent physical characteristics of shock waves, and how are they measured? These include significance and techniques of measurement of peak pressure, rise times, focal zone, isodose fall-off, and wave form. What are the best parameters to characterize the shock wave field? What are the best measures of efficacy of stone disintegration?

BIOEFFECTS

What are the mechanisms and determinants of tissue injury during shock wave therapy? The phenomenon of cavitation requires more elucidation. What are the interactions between shock frequency, total number of shocks, and initial pressure on tissue damage and repair processes? On pain perception? How are shock waves transmitted in water versus air versus tissues, and what effects do they display as they cross tissue-skin-air interfaces?

THE LITHOTRIPTER: DESIGN FEATURES

FUNCTIONAL COMPONENTS OF A LITHOTRIPTER SYSTEM

These include:

The energy source or type of shock wave generator
The focusing or reflecting device
The coupling medium
The image localization technique (i.e., ultrasound, fluoroscopy).

What are the advantages, disadvantages, and tradeoffs?

CATEGORIES OF SHOCK WAVE GENERATORS

These categories include the basic concept and design of an immersion spark-gap generator, electromagnetic acoustic generator, piezoelectric generator, micro-explosive generator. What are the unique properties of each, their strengths, their problems?

METHODS FOR MEASUREMENT, COMPARISON, AND STANDARDIZATION

At present, clinical in vivo quality assurance of shock wave production is relatively primitive. Physical measurement observations are relied upon rather than internal electronic or computer generated fail-safe controls. Attempts at standardization are thwarted by company-specific measuring techniques, disclosure, patent, and country of origin issues. On-line quality assurance to ascertain the pressure front output for clinical site operations is the bottom line. Industry wide standardization of operating parameters would be of value.

THE STONE

MECHANISMS OF STONE FRAGMENTATION

What are the differences between kidney stones and gallstones, relative to their susceptibility to lithotripsy (hardness or crystallinity in the matrix)? How are these measured, and how are they modeled in the research laboratory? What is the physical mechanism by which the tensile and shock forces interact within a stone? What is the relationship between the front wall and back wall reverberation effects? What is meant by spallation as a mechanism of stone disintegration? What is cavitation; and how do bubbles form, enlarge, and collapse? How real is the piezo-electric disruption effect in terms of

its surface active erosion rather than pure fragmentation? What about the ability to predict susceptibility of a stone or stones to fragmentation?

CLINICAL DISTINCTIONS BETWEEN GALLSTONE AND KIDNEY STONE LITHOTRIPSY

These distinctions include the need for ultrasonic rather than fluoroscopic localization; the probable necessity of adjuvant solvent therapy to dissolve gallstone fragments, even though no solvent therapy is generally required for kidney stone fragments; and at the present time, the much more rapid elimination of kidney fragments (3 months) versus gallstone fragments (6 to 18 months).

THE TREATMENT

ANESTHESIA

Although early lithotripsies were done with patients under general or epidural anesthesia, the industrywide standard has moved to the concept of anesthesia-free lithotripsy. Introduced by the piezoelectric companies, this concept has now been adopted by manufacturers of spark-gap systems. Principal physical factors controlling pain perception include lower total shock wave energy and a wider reflector aperture, which distributes the energy more diffusely over the somatic pain receptors at the skin surface. Nearly pain-free or anesthesia-free procedures can thus be accomplished, and as a result most patients will be treated on an out-patient basis. What are the down-side issues, if any, of the need for less analgesia?

POSITIONING

What will be the optimum patient position for lithotripsy vis-à-vis ease and reliability of an acoustic window with stones positioned appropriately at the same time? Initially, there has been a general preference for the prone position, but patient tolerance may be limited. How will these considerations fit with existing system design features?

THE GALLBLADDER

FRAGMENT PASSAGE

Early clinical results from Munich indicate that 3 to 18 months may be required for fragment passage, depending on the original stone burden.[2] Factors accounting for this prolonged delay probably include the scant daily volume of bile flow (vis-à-vis urine flow), the higher viscosity of bile, the narrow (2 to 3 mm), tortuous character of the cystic duct, the dependent position of fragments in the gallbladder fundus relative to the cystic duct, and the relative dysmotility of the gallbladder, especially in the weeks and months after lithotripsy. How much of a clinical problem does this create? How important is it to measure and quantitate fragment burden and rate of passage? Can this be accurately achieved?

THE FRAGMENTS

ADJUVANT THERAPY

The prolonged time for elimination of gallstone fragments has prompted interest in adjuvant therapy to speed the process. Adjuvant therapy could include the use of contact dissolution with MTBE and direct transcutaneous suction, among several other methods. However, interventional instrumentation to remove gallstone fragments is a more formidable undertaking than ureteral instrumentation.

ROLE OF ORAL BILE ACIDS

Initial gallstone lithotripsy experience from European centers has generally included oral bile acid adjuvant therapy to speed dissolution and elimination of cholesterol fragments. Based on clinical experience with primary oral bile acid therapy, it is assumed that for stones of a given size, fragmentation will increase the surface area, accelerating the rate of dissolution (Fig 1). The absolute necessity of adjuvant bile