1. Extracorporeal Shock Wave Lithotripsy:
Past, Present, and Future

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Introduction

Extracorporeal shock wave lithotripsy (ESWL) utilizing the Dornier HM₁ lithotripter has rapidly altered the management of upper urinary tract calculi with approximately 500,000 patients having been treated worldwide since the first human trials in Munich in February 1980.¹ The research leading to the development of the first ESWL device was performed by the Department of Urology, the Institute of Surgical Research, University of Munich, and Dornier GmbH, Friedrichshafen, West Germany, from 1974 to 1980.¹ The first human prototype (HM₁) was actually the fifth lithotripter produced by Dornier.⁴ Between 1980 and 1983, approximately 1,200 patients were treated on the HM₁ and HM₂ lithotripters,¹ culminating in the development of the HM₃ lithotripter. There are now more than 250 of these machines distributed in 28 countries.

At the end of 1983, with the reproduction and reliability of the technology proved to our satisfaction, establishment of additional treatment centers began in Germany, followed by placement of the first ESWL unit in the United States at the Methodist Hospital of Indiana in Indianapolis in February of 1984. The impact and success of this technology was such that the Dornier HM₃ lithotripter was approved by the U.S. Food and Drug Administration in December 1984.

Following the successful introduction of the Dornier kidney stone lithotripter, much attention has been focused on the development of similar technology for the treatment of cholelithiasis. In this presentation, I would like to review the status of kidney stone ESWL, which is now routine therapy, and present a view of the future of gallstone ESWL. In addition, areas of research utilizing ESWL will be mentioned.

Indications for ESWL: 1988

When kidney stone lithotripsy began in 1980, only about 20% of patients were considered appropriate candidates for this new form of therapy.² These were patients with single, renal pelvic or calyceal stones less than 10 mm in diameter. Between 1980 and the present, the indications for ESWL have rapidly expanded, and currently 80% to 85% of all patients with symptomatic upper urinary tract calculi may be considered appropriate candidates for ESWL, with or without the concomitant use of indwelling ureteral stents (Fig. 1-1). Ureteral stents should be considered in patients with large stone burdens, ureteral stones, and radiolucent stones. ESWL may also be combined with percutaneous nephrolithotomy (PCN) for the treatment of complete staghorn stones and coexisting obstructive lesions of the upper urinary tract (such as ureteropelvic junction obstruction). A small number of patients with kidney stones (3% to 5%) may still be appropriate candidates for open surgical therapy.

Indications for the treatment of ureteral stones came only after demonstration that kidney stones could be fragmented in 98% to 99% of cases.⁵ Naturally, the treatment of upper ureteral stones and then, finally, distal ureteral stones was included in the indications for ESWL. Reposition-
ing of ureteral stones into the kidney prior to ESWL improves fragmentation. Because of differences in treatment philosophy and economic systems, in situ ESWL as initial therapy is preferred in Europe whereas attempts at stone repositioning followed by ESWL are preferred in the United States. In either instance, a successful result eventually may be expected (Table 1-1). Our experience at UCLA has demonstrated that the passage of a ureteral catheter or stent enhances stone destruction with ESWL.

The treatment of staghorn stones remains controversial. Our study of ESWL monotherapy in a series of staghorn stones treated at UCLA revealed that nondilated renal collecting systems could be treated successfully in 88% of cases. In mildly dilated renal collecting systems, the success rate was 62%, and dilated renal collecting systems could be treated successfully in only 52% of cases. The treatment of larger staghorn calculi in dilated renal collecting systems is possible with a combination of PCN and ESWL. At UCLA an average of 2.8 treatment sessions per case was required. The average patient received a total of 2,600 shock waves, and auxiliary ureteroscopic procedures for the management of steinstrasse were necessary in 6% of patients. Overall, 81% of patients became stone free using this method of treatment.

An important issue for all manufacturers of ESWL equipment is the reproducibility of the technique. With the Dornier HM, lithotripter, stone fragmentation rates consistently greater than 98% were achieved following worldwide distribution of the technology (Table 1-2). The impact of this impressive engineering and medical achievement on the treatment of nephrolithiasis in the Munich Stone Center is presented in Fig. 1-2.

Although the Dornier HM lithotripter has been remarkably successful, treatments with the original generator and ellipsoid (15.6 cm) required regional or general anesthesia in most instances. Further refinement of the lithotripter employing a wider ellipsoid (17 cm) and a generator with lower power (40 nanofarads) now allows most patients receiving ESWL with Dornier lithotripters to be treated with intravenous sedation/narcotics or no anesthesia at all. However, treatment with lower-pressure ESWL has resulted in an increase in the re-ESWL rate ranging from 10% to 25%, in comparison with the 40% to 70% retreatment rate reported for most units utilizing piezoelectric systems.

### Contraindications to ESWL

The current contraindications for ESWL are listed in Table 1-3. Even these contraindications are gradually being eliminated. For example, patients may now be offered ESWL without the requirement for regional or general anesthesia, making almost any patient, no matter how high the

### Table 1-1. Success rates of ESWL treatment of ureteral stones in relation to stone location.

<table>
<thead>
<tr>
<th>Stone Location</th>
<th>n</th>
<th>Successful Disintegration</th>
<th>Stone Free at 2 wks</th>
<th>Stone Free at 3 mths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ureteral stones repositioned into renal collecting system</td>
<td>71 (59.0%)</td>
<td>100.0%</td>
<td>85%</td>
<td>98%</td>
</tr>
<tr>
<td>Upper ureter + stent</td>
<td>33 (27.0%)</td>
<td>94.6%</td>
<td>92%</td>
<td>99%</td>
</tr>
<tr>
<td>Mid ureter + stent</td>
<td>11 (7.5%)</td>
<td>91.2%</td>
<td>89%</td>
<td>99%</td>
</tr>
<tr>
<td>Upper ureter, no stent</td>
<td>6 (4.4%)</td>
<td>33.0%</td>
<td>25%</td>
<td>33%*</td>
</tr>
<tr>
<td>Mid ureter, no stent</td>
<td>2 (2.1%)</td>
<td>50.0%</td>
<td>50%</td>
<td>50%*</td>
</tr>
</tbody>
</table>

* The remaining kidneys were rendered stone free after auxiliary procedures.