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REVIEW ARTICLE

From ‘stone cutting’ to high-technology methods: The changing face of stone surgery

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Introduction

The surgical management of urolithiasis, in particular cystolithiasis, has been known for more than two millennia. The term *lithotomy* was first used by the Greek surgeon Ammonius (276 BCE), but the practice of *cutting the stone* would have existed long before that. However, Hippocrates (460 BCE) discouraged the procedure. His oath reads: ‘*I will not cut persons labouring under the stone, but will leave this to be done by practitioners of this work*’. Most probably he wished to disassociate himself from this frequently unsuccessful procedure, in an attempt to prevent it from tarnishing the physicians’ reputation.

The Roman physician Celsus (25 BCE–25 CE) provided the earliest proper description of a lithotomy procedure for bladder stones. Notably, his description remained broadly accurate for the techniques used over the next 1500 years. The procedure remained associated with a relatively poor suc-

cess rate, with frequent and often unpleasant complications, such as damage to the rectum or bladder, and death.

Only over the last 150 years, with the techniques of asepsis and anaesthesia, has more complex surgery become possible. For almost all stones in the urinary tract, open surgical procedures have been developed and applied. The invention of cystoscopy allowed the endoscopic removal of bladder stones [1]. Then, over the last three decades the development of endourological and nonsurgical less-invasive techniques, such as ESWL, percutaneous nephrolithotomy (PCNL), ureterorenoscopy (URS) including flexible retrograde intrarenal surgery, and (more recently but to a lesser extent) laparoscopy, have revolutionized stone treatment and led to a marked decrease in the need for open stone surgery [2,3].

The need for state-of-the-art stone surgery: an example from the United Arab Emirates (UAE)

In much of the so-called developing world a Western lifestyle is increasingly being adopted. This can include a sedentary lifestyle, an increased intake of fat and animal proteins, an increase in stress level, smoking, alcohol intake and others, all of which enhance a predisposition to stone formation directly or indirectly. An increased body mass index, diabetes mellitus, gout, metabolic syndrome (obesity, insulin resistance, diabetes

Abbreviations: PCNL, percutaneous nephrolithotomy; UAE, United Arab Emirates; URS, ureterorenoscopy

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or pre-diabetes, hypertension and high lipids) and other 'civilatory' diseases contribute further [4]. In addition, most of Middle East and adjacent countries are situated in the so-called 'stone belt', characterised by a hot subtropical or dry climate and a high incidence of stone formation. In the 'Western' world the lifetime chance of an individual to develop urolithiasis has been estimated at 12% [5], the incidence at 0.5% of the population per year, and the stone-related morbidity at 2–3% [6]. Recurrence rates are estimated at about 10% per year, totalling 50% over a 5–10-year period, and 75% over 20 years [7]. The incidence rate increases to 20–25% in the Middle East, because of increased risk of dehydration in hot climates (the typical Middle Eastern diet is also 50% lower in calcium and 250% higher in oxalates than are Western diets, increasing the net risk) [8]. Stone disease comprises well over 50% of the urological workload in 'stone belt' countries [9].

The total population of the UAE in 2010 is recorded as 8.2 million. In Dubai, the most crowded centre within the UAE, it is 1.87 million [10]. Thereof, $\approx 8\%$ are expatriates from Europe, USA, or the far East [11]. In turn, 92% of the population (including the $\approx 20\%$ local Emirates) are from the stone belt, and have therefore an increased risk of stone formation. In addition, the male: female ratio in the UAE is skewed, at 2.7 [12]. Males in non-Western societies are still more at risk of stone formation than females. However, through changes in lifestyle, females in the so-called developed world are catching up rapidly on the risk of stone of and other 'civilatory' diseases.

On the basis of these statistics the projected number of cases of stone (up to 25% incidence in the population at risk) in the UAE would be 1889,440 new cases per year, not including re-treatments and staged treatments, and 430,848 in Dubai alone. This also does not take into account the $> 10\%$ recurrence rate after 1 year, rising to 50% after 5 years and to 75% (!) after 20 years [7].

Stone-belt countries have and will have a very significant urological workload of stone disease. In the interest of the patients it is highly desirable that a switch to modern minimally invasive treatment methods can be effected and spread. In the interest of the countries' health policies and economics it is also desirable to keep those stone patients inside the country who currently could afford to go abroad to seek treatment. Of course this will only happen when technology and skills are made available locally. According to a recent survey, some 70% of UAE residents would prefer to seek medical treatment abroad if they became seriously ill and could afford it [13]. Some governments have recognised this need and started endeavours to make such a change happen [14]. In the light of such huge numbers of stone patients this seems to be a long overdue but fruitful investment in the future.

The changing face of stone surgery

Two decades ago, the rate of open stone surgery was reported as 26% in a tertiary referral centre in Pakistan [15], and 3–5% in the USA [3,16]. More recently, this rate has decreased to 8% in Pakistan [15], and 0.7–2% in centres of the so-called developed world [17–19]. These are now mostly nephrectomies for nonfunctioning kidneys, or reconstructive surgery for complications resulting from stone disease [1]. Notably, these are data from tertiary referral centres in their respective countries, and there will be a difference between these centres and rural

hospitals, in particular in the developing world, where in many places open surgery is still primarily performed.

This is certainly related to the fact that minimally invasive technology and learning opportunities to develop the associated skills are not as readily available in developing countries. However, the trend worldwide becomes clear; a dramatic reduction in open stone surgery with a simultaneous increase in less-invasive procedures such as ESWL, PCNL, URS and laparoscopy [1].

This is reflected and has been supported by the establishment of endourological subspecialty organizations such as the International Endourology Society, the subspecialization accreditation of the European Board of Urology, and subspecialized sections of international and national bodies such as the section of uro-technology and the section of urolithiasis of the European Association of Urology, and the section of endourology of the British Association of Urological Surgeons, to name but a few. These organizations attempt to further the use of technology in stone treatment, training in minimally invasive stone surgery, and research into urolithiasis.

Whereas 99% of stones are currently treated by minimally invasive methods in the so-called developed world ($\approx 80\%$ by ESWL, and 10% each with PCNL or URS) the current remaining indications for open stone surgery can be complex stone disease [3,17–19], concomitant anatomical abnormalities such as PUJ obstruction, infundibular stenosis or calyceal diverticulum [3,17–19], failure of minimally invasive treatments [3,16,17,19], morbid obesity [3,16,19], comorbid medical diseases [3,19,20], concurrent open surgery [3,16,19,20], renal transplantation [16], severe limb contractures [16] and patient preference [17]. However, with improving expertise and technologies many subspecialized stone centres could also increasingly accept these patients for minimally invasive treatment. Moreover, to date there is a lack of guidelines as to when open stone surgery should be used. Over the last three decades the development of minimally invasive stone surgery has progressed so rapidly and been adopted that no properly randomized studies have been conducted. Therefore, these remaining indications are relative and empirical [21].

As mentioned above, developing countries have a slightly different situation, with 8–14% treated by open stone surgery to date [15,22]. Factors responsible are [17]:

(i) unavailability of equipment for non- and minimally invasive techniques; (ii) increased emphasis on cost (which is born at least in part by the patient) and the consequent desire for a single procedure and (iii) later presentation and therefore more complex cases.

A glimpse into the future

Because of the above mentioned restrictions, open stone surgery will keep its place in the so-called developing world for some time to come. However, there is a keen interest in many countries and centres around the world to catch up with these developments, and many initiatives are underway worldwide to enable surgeons to gain the necessary skills and/or acquire the necessary infrastructure.

By contrast, in the so-called developed world open stone surgery will all but disappear. Stone treatment will switch to tertiary subspecialized stone centres and almost all stone-related pathologies will be managed with minimally invasive

techniques. These centres will at the same time provide subspecialty training for future minimally invasive stone surgeons.

Open stone surgery will be reserved for highly complex and unusual cases. It can be postulated that the subspecialized minimally invasive stone surgeon of the future might no longer have the skills needed for this kind of surgery, and selected patients will therefore need referral to open reconstructive urological surgeons to assist [1].

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