Comparative study between dusting versus fragmentation of proximal ureteric stones using Holmium Laser Lithotripsy

Thesis

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Introduction

Urinary stone disease is the third most common entity following urinary tract infection and prostate diseases among urinary disorders. The prevalence of kidney stone disease has increased in the modern era due to the effects of increasing obesity, diabetes, and changes in dietary habits on urinary stone formation (***Scales et al., 2012***).

Urolithiasis is a common medical problem with a prevalence of approximately 2% to 3% in the general population. 50% of patients with previous urinary stones have a recurrence within 10 years ***(Wilkinson, 2001).***

While minimally invasive therapies remain the mainstay of treatment, there has been a notable increase in the use of ureteroscopy (URS).The classic treatment strategies for the ureteral stones are, watchful waiting with CTUT follow-up for ureteral stones with a diameter of < 5 mm, Extracorporeal shock wave lithotripsy (ESWL),ureteroscopy, open surgery, laparoscopic ureterolithotomy ***(Lingeman and Matlaga, 2010).***

Flexible ureteroscopy can be more efficacious in the treatment of proximal ureteral stones with the advantage of high clearance rate and less complications ***(Liu et al., 2013).***

One reason for the shift in practice toward URS has been the widespread availability of the holmium laser, which permits lithotripsy in all stone locations, regardless of stone composition. With the propagation of more powerful higher watt holmium systems and advances in laser technology, the options available to surgeons for laser settings and techniques to break up stones have expanded (***Rassweiler et al., 2016***).

The several techniques of Laser lithotripsy as dusting and fragmentation depends on Laser lithotripsy settings. That includes pulse energy, frequency and pulse width. Stone dusting settings are decreasing energy and increasing frequency resulting in converting a stone to dust or tiny fragments to allow these tiny fragments to pass spontaneously. Stone fragmentation is to convert the stone to visible fragments which can be extracted with forceps and baskets by increasing energy and decreasing frequency. There are 2 types of pulse width, short and long, the difference between them is that long pulse width decrease stone retropulsion and has protective effect on laser fiber tip degradation as it decreases fiber burnback (***Chew et al., 2016***).

In this thesis, we will study the results of dusting and fragmentation techniques of holmium Laser lithotripsy including operation time, stone migration, bleeding, perforation and stone free rate.

AIM OF THE WORK

The aim of this work is to compare between proximal ureteric stones disintegration using dusting vs. fragmentation technique regarding the outcome and the complications such as operative time, stone migration, bleeding, perforation and stone free rate.

Chapter One

URINARY STONES

I. Epidemiology of urinary stones

Approximately 10% of Caucasian men will develop a kidney stone by the age of 70. Within 1 year of a calcium oxalate stone, 10% of men will form another calcium oxalate stone, and 50% will have formed another stone within 10 years. The prevalence of renal tract stone disease is determined by factors intrinsic to the individual and by extrinsic (environmental) factors. A combination of factors often contributes to the risk of stone formation ***(Yasui et al., 2013).***

1- Intrinsic factors

A-Age

Peak incidence of stones occurs between the ages of 20 and 50 years ***(Hiatt, 1982).***

B- Sex

Males are affected 3 times as frequently as females. Testosterone may cause increased oxalate production in the liver (predisposing to calcium oxalate stones) and women have higher urinary citrate concentrations (citrate inhibits calcium oxalate stone formation) ***(Hiatt, 1982).***

C- Genetic

Kidney stones are relatively uncommon in Native Americans, Black Africans, and U.S. Blacks, and more common in Caucasians and Asians. About 25% of patients with kidney stones report a family history of stone disease (the relative risk of stone formation remaining high after adjusting for dietary calcium intake). Familial renal tubular acidosis (predisposing to calcium phosphate stones) and cystinuria (predisposing to cystine stones) are inherited ***(Curhan et al., 2003).***

2- Extrinsic (environmental) factors

A- Geographical location, climate, and season

The relationship between these factors and stone risk is complex. While renal stone disease is more common in hot climates, some endogenous populations of hot climates have a low incidence of stones (e.g., Black Africans), and many cold areas have a high incidence of stones (e.g., Northern Europe and Scandinavia). This may relate to Western lifestyle (excess food, inadequate fluid intake, limited exercise) combined with a genetic predisposition to stone formation ***(Kim et al., 2007).***

Ureteric stones become more prevalent during the summer. The highest incidence occurs a month or so after peak summer time temperatures, presumably because of higher urinary concentration in the summer (encourages crystallization). Concentrated urine has a lower pH, encouraging cystine and uric acid stone formation. Exposure to sunlight may also increase endogenous vitamin D production, leading to hypercalciuria ***(Curhan et al., 2003).***

B- Water intake

Low fluid intake (<1200 mL/day) predisposes to stone formation. Increasing water hardness (high calcium content) may reduce risk of stone formation by decreasing urinary oxalate ***(Borghi et al., 2002).***

C- Diet

High animal protein intake increases risk of stone disease (high urinary oxalate, low pH and low urinary citrate). High salt intake causes hypercalciuria. Contrary to conventional teaching, low-calcium diets predispose to calcium stone disease, and high-calcium intake is protective. The inverse relationship between low dietary calcium intake and an increase in stone formation is likely due to a secondary increase in urinary oxalate. Oxalate absorption occurs throughout the intestinal tract .When calcium and oxalate are consumed at the same meal, a calcium-oxalate complex forms within the intestinal tract limiting the intestinal absorption and subsequent urinary excretion of free oxalate. And so with dietary calcium restriction, free oxalate becomes increasingly available for intestinal absorption, leading to greater urinary excretion of oxalate. ***(Curhan et al., 2003).***

D- Occupation

Sedentary occupations predispose to stones more than manual work ***(Curhan et al., 2003).***

II. Urinary stones types and predisposing factors

Stones may be classified according to composition, X-ray appearance, or size and shape.

1- Radiodensity on X-ray

Three broad categories of stones are described, based on their X-ray appearance. This gives some indication of the likely stone composition and helps to some extent to determine treatment options. However, in only 40% of cases is stone composition correctly identified from visual estimation of radiodensity on plain X-ray ***(Kim et al., 2007).***

A- Radio-opaque

Opacity implies presence of substantial amounts of calcium within the stone. Calcium phosphate stones are the most radiodense stones, almost as dense as bone. Calcium oxalate stones are slightly less radiodense***(Kim et al., 2007).***

B- Relatively radiodense

Cystine stones are relatively radiodense because they contain sulfur. Magnesium ammonium phosphate (struvite) stones are less radiodense than calcium-containing stones***(Kim et al., 2007).***

C- radiolucent

Uric acid, triamterene and xanthine. Indinavir stones are in this category and cannot be visualized even on pelviabdominal CT without contrast ***(Kim et al., 2007).***

Table (1): Composition of renal stones ***(Kim et al., 2007).***

Stone composition	% of all renal calculi*
Calcium oxalate	85%
Uric acid†	5–10%
Calcium phosphate + calcium oxalate	10%
Pure calcium phosphate	Rare
Struvite (infection stones)	2–20%
Cystine	1%

* The precise distribution of stone types will vary depending on the characteristics of the study population (geographical location, racial distribution, etc.). Hence, the quoted figures do not equate to 100.

†~80% of uric acid stones are pure uric acid; 20% contain some calcium oxalate.

2- Size and shape

Stones can be characterized by their size, in centimeters. Stones that grow to occupy the renal collecting system (the pelvis and one or more renal calyx) are known as staghorn calculi, since they resemble the horns of a stag. They are most commonly composed of struvite—magnesium ammonium phosphate (being caused by infection and forming under the alkaline conditions induced by urea-splitting bacteria), but may consist of uric acid, cystine, or calcium oxalate monohydrate ***(Wang et al., 2009).***

Figure (1): Staghorn stone ***(Wang et al., 2009).***

Management of upper ureteric stone

Technological advances have changed profoundly the management of ureteral stones. Before 1980, open surgical ureterolithotomy was the only option available for the treatment of upper third ureteral stones. Current minimally invasive options are so reliable and safe that open ureterolithotomy is rarely indicated for the treatment for upper urinary tract calculi ***(Chaussy et al., 1982)***

1- Conservative management of upper third ureteral stones

The natural history of ureteral stone has been analyzed by several investigators, and variable rates of spontaneous upper ureteral stone passage have been reported. Most studies agree that stones with a diameter of 5 mm or less have a high probability of spontaneous passage. Rates ranging from 29 to 98% have been reported. The 2 main factors that influence spontaneous stone passage are size and location of the stone, assuming that there is no anatomical abnormality involving the ureter ***(Miller* and Kane, *1999).***

2- Surgical management of upper third ureteral stones

Surgical intervention should be instituted immediately in patients with intractable pain, severe obstruction, signs of infection, or failure of stones progression after 3 to 4 weeks. Even for small stones, if passage has not happened after this period, spontaneous passage is unlikely and therefore surgical intervention will likely be required ***(Segura et al., 2003).***

Five modalities of treatment are currently available for management of upper third ureteral stones: extracorporeal shock wave lithotripsy, retrograde ureteroscopy, antegrade ureteroscopy (percutaneous), laparoscopic ureterolithotomy, and open surgical ureterolithotomy ***(Segura et al., 2003).***

A- Extracorporeal shock wave lithotripsy

Because of its non-invasiveness, efficacy, and safety, extracorporeal shock wave lithotripsy (SWL) quickly established itself as a mainstay for treatment of urinary calculi ***(Grasso et al., 2004).***

B- Retrograde Ureteroscopy

Retrograde ureteroscopy has the inherent advantage over the remaining intracorporeal techniques of being performed through the existing urinary tract. This approach requires facility with the equipment, but in the hands of a well-trained urologist is very effective and safe. Both rigid and flexible ureteroscopes can be used rigid ureteroscopes are offset by their inability to access the upper third ureter in many patients (usually men), and by the greater degree of ureteral manipulation that may be required. The technical capabilities of flexible ureteroscopes continue to advance, with improvements in optical quality, degree of active deflection, and durability ***(Tawfik* and Bagley, *1999).***

C- Antegrade Ureteroscopy

Antegrade flexible ureteroscopy is a melding of the techniques of percutaneous nephrostolithotomy and ureteroscopy. The technique combines the stability of access of the percutaneous procedure with the minimal trauma afforded by the small caliber ureteroscope. For large stones impacted in the upper third ureter, the retrograde ureteroscopic approach can be very challenging. The same stone can often be managed much more effectively with a ureteroscope “going down” on the stone, rather than “pushing up” on it as with retrograde ureteroscopy. Flexible lithotrites (laser, electrohydraulic) are used ***(Lee* and Smith, *2002).***

The goal of the lithotripsy is only to fragment stones into manageable pieces, since fragments can be pushed out into the bladder. This aspect of the antegrade approach markedly enhances efficiency compared to the retrograde approach, where the entire stone burden must be converted into fragments of less than 1 to 2 mm in diameter ***(Lee* and Smith *, 2002).***