Safety and Efficacy of Percutaneous Nephrolithotomy in Horseshoe Kidney

Thesis

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By

Ahmed Salah Kodera

M.B., B.CH.

Supervised by

Prof. Dr. Mohamed Y. ElGammal

Professor of Urology
Cairo University

Asst. Prof. Dr. Ashraf Abuelela El Said

Assistant Professor of Urology
Cairo University

Department of Urology

Cairo University

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ABSTRACT

We review our experience with percutaneous nephrolithotomy for stones in horseshoe kidneys when extracorporeal shock wave lithotripsy was unsuccessful or inappropriate because of stone burden.

MATERIALS AND METHODS: Stone burden, nephrostomy and percutaneous surgical techniques, and clinical outcome of ١٢ consecutive patients (١٤ renal units) undergoing percutaneous nephrolithotomy for calculi in horseshoe kidneys. The stone-free rate, complication rate, need for secondary interventions were evaluated.

RESULTS: Renal access was obtained through an upper pole calyx in ٥٧٪ of the cases and through a middle calyx in ٣٦٪. More than ١ nephrostomy tract was required in one patient. ١٢ out of ١٤ renal units (٨٦٪) were rendered stone-free after primary procedure. The incidence of major complications in our study is ٧٪. The only major complication met in our study was sepsis in a female patient with bilateral infection renal stones.

CONCLUSIONS: Percutaneous treatment of patients with renal calculi in a horseshoe kidney is technically challenging, usually requiring upper pole access and flexible nephroscopy, although not used in our study, due to the altered anatomical relationships of the fused renal units. The success rate based on stone-free results and a relatively low incidence of major complications suggest that this minimally invasive management option is an effective means of stone management in this complex patient population.

KEY WORDS: kidney, kidney calculi, lithotripsy, abnormalities, intraoperative complications

Chapter One

Introduction

Horseshoe kidney occurs in ٠,٢٥٪ of the population, or about ١ in ٤٠٠ persons ***(Glenn ˝ đ̃ đ).*** As with other fusion anomalies, it is found more commonly in males by a ٢:١ margin. The abnormality has been discovered clinically in all age groups ranging from fetal life to ٨٠ years, but in autopsy series it is more prevalent in children ***(Segura et al, ١٩٧٢).*** This early age prevalence is related to the high incidence of multiple congenital anomalies associated with the horseshoe kidney, some of which are incompatible with long-term survival.

During embryogenesis fusion of the lower poles prevents normal ascent and causes malrotation with anterior displacement of the collecting system. Insertion of the ureter on the renal pelvis is displaced superior and lateral, probably as the result of incomplete renal rotation, and it is associated with a significant rate of ureteropelvic obstruction. These factors contribute to impaired drainage of the collecting system, resulting in stasis, a higher incidence of infection (٣٠٪) and a predisposition to calculus formation. The incidence of stone formation in horseshoe kidneys has been reported to be approximately ٢٠٪ ***(Raj et al, ˜ ˜ ˜ ˜).*** Historically the most common etiology for stone formation in horseshoe kidneys was believed to be secondary to urinary tract infection and urinary stasis due to the anterior location of the renal pelvis, abnormal ureteral course over the isthmus and occasionally high ureteral insertion. Evans and Resnick studied the incidence of urolithiasis in ٨ patients with horseshoe kidney. In ٦ patients a

treatable metabolic abnormality was the etiology of stone disease, while in the remainder struvite stones formed. Evans and Resnick observed that most patients have underlying metabolic abnormalities that contribute to stone formation and, therefore, those with stone disease in a horseshoe kidney should undergo metabolic evaluation to minimize recurrence. The study of Mottola et al also supports this observation ***(Yohannes & Smith,)***

Chapter Two

Embryology of the kidney

Development of Three Embryonic Kidneys

Mammals develop three kidneys in the course of intrauterine life. The first two kidneys regress in utero, and the third becomes the permanent kidney. Embryologically speaking, all three kidneys develop from the intermediate mesoderm. As the embryo undergoes transverse folding, the intermediate mesoderm separates away from the paraxial mesoderm and migrates toward the intraembryonic coelom (the future peritoneum). At this time, there is also progressive craniocaudal development of the bilateral longitudinal mesodermal masses called nephrogenic cords. Each cord is seen bulging from the posterior wall of the coelomic cavity, producing the urogenital ridge.

Pronephros

The mammalian pronephros is a transitory, nonfunctional kidney, analogous to that of primitive fish**.** In humans, the first evidence of pronephros is seen late in the ٣rd week, and it completely degenerates by the start of the ٥th week. The pronephroi develop as five to seven solid cell groups in the cervical region.

Mesonephros

The second kidney, the mesonephros is also transient, but in mammals it serves as an excretory organ for the embryo while the definitive kidney, the metanephros, begins its development. During regression of the pronephric system, the first excretory of the mesonephros appear. They lengthen rapidly, form an S-shaped loop, and acquire a glomerulus at their medial extremity. Here the tubule forms Bowman's capsule. The capsule and glomerulus together form renal corpuscle. At the opposite end, the tubule enters the longitudinal collecting duct, known as the mesonephric or Wolffian duct. In the middle of the ٢nd month, the mesonephros forms a large ovoid organ on each side of the midline. Since the developing gonad is located on its medial side, the ridge formed by both organs is known as the urogenital ridge. While the caudal tubules are differentiating, the cranial tubules and glomeruli show degenerative changes and, by the end of the ٢nd month, the majorities have disappeared. A few of the caudal tubules and mesonephric duct, however, persist in the male, but disappear in the female ***(Sadler,).***

Metanephros

The definitive kidney, or the metanephros forms in the sacral region as a pair of new structures, called the ureteric buds, sprouts from the distal portion of the mesonephric duct and comes in contact with the blastema of metanephric mesenchyme at about the ٢٨th day. The ureteric bud penetrates a condensing metanephric mesenchyme and begins to divide. The tip of the dividing ureteric bud, called the ampulla, interacts with the metanephric mesenchyme to induce formation of future nephrons. As the ureteric bud

divides and branches, each new ampulla acquires a cap-like condensation of metanephric mesenchyme, thereby giving the metanephros a lobulated appearance.

The metanephric mesenchyme induces the ureteric bud to branch, and, in turn, the ureteric bud induces the metanephric mesenchyme to condense and undergo mesenchymal-epithelial conversion. The nephron, which consists of the glomerulus, proximal tubule, loop of Henle, and distal tubule, is thought to derive from the metanephric mesenchyme, whereas the collecting system, consisting of collecting ducts, calyces, pelvis, and ureter, is formed from the ureteric bud.

Development of the Collecting System

The bifurcation of the ureteric bud determines the eventual pelvicalyceal patterns and their corresponding renal lobules. The first few divisions of the ureteric bud give rise to the renal pelvis, major and minor calyces, and collecting ducts. Thereafter, the first generations of collecting tubules are formed. When the ureteric bud first invades the metanephric mesenchyme, its tip expands to form an ampulla that will eventually give rise to the renal pelvis. By the ٦th week, the ureteric bud has bifurcated at least four times, yielding ١٦ branches. These branches then coalesce to form two to four major calyces extending from the renal pelvis. By the ٧th week, the next four generations of branches also fuse, forming the minor calyces. By the ٣٢nd week, approximately ١١ additional generations of bifurcation have resulted in approximately ١ to ٣ million branches, which will become the collecting duct tubules.

Renal Ascent

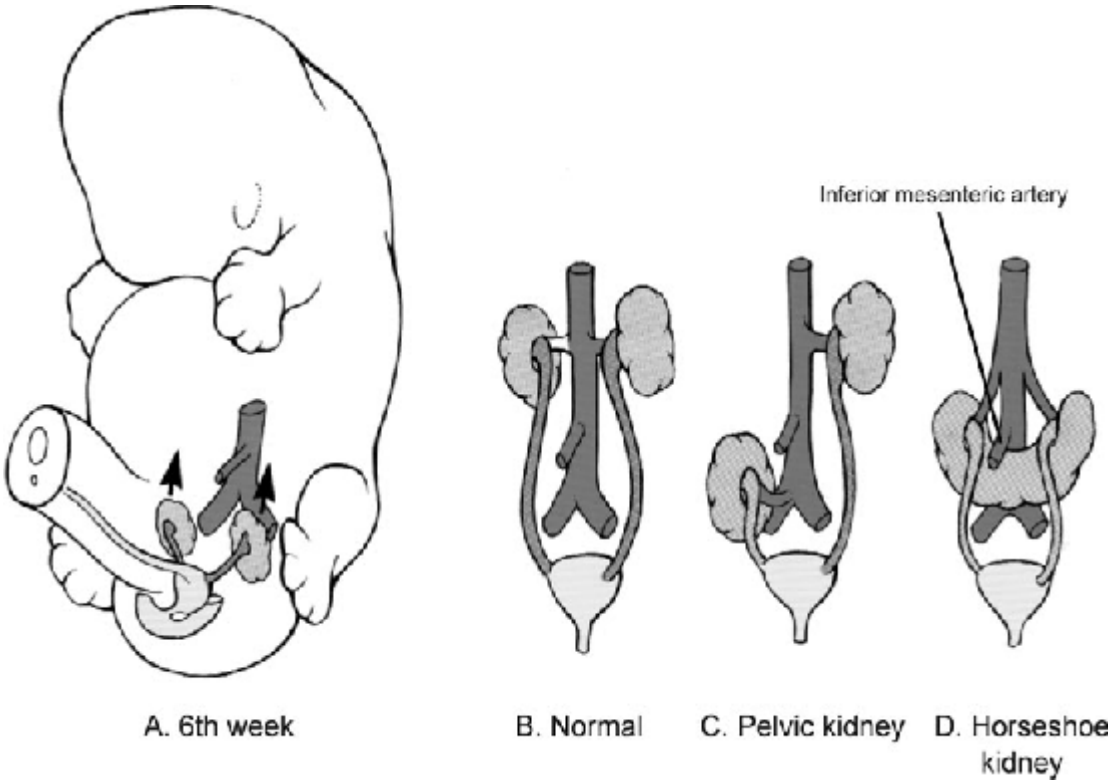

Figure ( ): **Renal Ascent** ***(Park,   )***

Between the ٦th and ٩th weeks, the kidneys ascend to a lumbar site just below the adrenal glands. The precise mechanism responsible for renal ascent is not known, but it is speculated that the differential growth of the lumbar and sacral regions of the embryo plays a role. As the kidneys migrate, they are vascularized by a succession of transient aortic sprouts that arise at progressively higher levels. These arteries do not elongate to follow the ascending kidneys, but instead degenerate and are replaced by successive new arteries. The final pair of arteries forms in the upper lumbar region and becomes the definitive renal arteries. Occasionally, a more inferior pair of

arteries persists as accessory lower pole arteries. When the kidney fails to ascend properly, its location becomes ectopic. If its ascent fails completely, it remains as a pelvic kidney. The inferior poles of the kidneys may also fuse, forming a horseshoe kidney that crosses over the ventral side of the aorta. During ascent, the fused lower pole becomes trapped under the inferior mesenteric artery and therefore does not reach its normal site ***(Park,*** ***)***

The horseshoe kidney

The commonest of all renal fusion anomalies is probably the horseshoe kidney. The two distinct renal masses lie vertically on either side of the midline and are connected at their respective lower poles by a parenchymatous or fibrous isthmus that crosses the midplane of the body. It was first recognized during an autopsy by DeCarpi in ١٥٢١, but Botallo in ١٥٦٤ presented the first extensive description and illustration of a horseshoe kidney ***(Benjamin & Schulian,*** ***).*** The abnormality occurs between the ٤th and ٦th week of gestation, after the ureteral bud has entered the renal blastema. In view of the ultimate spatial configuration of the horseshoe kidney, the entrance of the ureteral bud had to have taken place before rotation and considerably before renal ascent ensued. Boyden (١٩٣١) described a ٦-week-old embryo with a horseshoe kidney, the youngest fetus ever discovered with this anomaly. He postulated that at the ١٤-mm stage (٤,٥ weeks), the developing metanephric masses lie close to one another; any disturbance in this relationship might result in joining at their inferior poles ***(Boyden,*** ***)*** A slight alteration in the position of the umbilical or common iliac artery could change the orientation of the migrating kidneys,

leading to contact and fusion. It has been postulated that an abnormality in the formation of the tail of the embryo or another pelvic organ could account for the fusion process ***(Cook & Stephens, ١٩٧٧)*** Domenech-Mateu and Gonzales-Compta (١٩٨٨), after studying a ١٦-mm human embryo, suggested that posterior nephrogenic cells migrate abnormally to form an isthmus or connection between the two developing kidneys to create the horseshoe shape ***(Domenech-Mateu & Gonzales-Compta,*** [illegible] ***)*** Whatever the actual mechanism responsible for horseshoe kidney formation, the joining occurs before the kidneys have rotated on their long axis**.** In its mature form, the pelves and ureters of the horseshoe kidney are usually anteriorly placed, crossing ventrally to the isthmus. Very rarely, the pelves are anteromedially, suggesting that fusion occurred somewhat later, after some rotation had taken place. In addition, migration is usually incomplete, with the kidneys lying lower in the abdomen than normal. It is presumed that the inferior mesenteric artery prevents full ascent by obstructing the movement of the isthmus.

Chapter Three

Renal Anatomy

Endourologic Considerations

The urologist must have a thorough knowledge of the renal anatomy and the relationship to the surrounding structures. A dynamic perception of the stereotactic configuration is considered necessary to avoid complications during percutaneous renal surgery.

General Anatomy

The kidneys are paired organs that lie retroperitoneally on the posterior abdominal wall. Each kidney is of a characteristic shape, having a superior and inferior pole, a convex border placed laterally, and a concave medial border. The medial border has a marked depression, the hilum, which contains the renal vessels and the renal pelvis ***(Elspeth et al,*** ***)***

Position of the kidneys

Because the kidneys lie in the posterior abdominal wall against the psoas major muscle, their longitudinal axis parallels the oblique course of the psoas. Because the psoas muscle is conical, the kidneys also are dorsally inclined on the longitudinal axis. Therefore, the superior poles are more medial and more posterior than the inferior poles. Because the hilar region is