INTRODUCTION

Background
• Optimal management of patients with complex renal stones remains challenging;
• Stone-free rates following percutaneous nephrolithotomy (PCNL) in patients with staghorn stones vary from 47% to 67%;
• Anatrophic nephrolithotomy with robotic assistance may represent a viable option in patients in whom the stone is not expected to be removed by a reasonable number of PCNL and/or ancillary procedures.

Objectives
• Three-fold:
  1. To test feasibility & develop a novel technique of RANL for treatment of complex renal stones, in a patient conscientious manner utilizing the IDEAL guidelines for surgical innovation;
  2. Evaluate utility of Firefly (Near Infra-red Fluorescence Imaging - NIRF) in identification of the anatrophic plane;
  3. Develop a reliable and reproducible in vivo stone model.

METHODS

Subjects
• Two domestic porcine females (~20 kg each).

Technique
• Robot was docked in flank position utilizing two robotic ports, with a mini-GeiPOINT in the midline for assistant port (Figure 1);
• The renal artery was dissected carefully to define anterior and posterior divisions;
• For creating the stone, low viscosity DenMat Precision material (DenMat Inc., Santa Maria, CA) was injected into the renal pelvis through an incision, via a 14F Foley catheter introduced through the assistant port; following injection, the catheter was withdrawn and renal pelvis closed with suture;
• Next, the posterior segment of the renal artery was clamped and 2 mg of indocyanine green was given IV to aid in identification of the anatrophic plane using near infra-red fluorescence (NIRF) image-guidance (Firefly);
• The hilar vessels were clamped and RANL performed;
• For cold ischemia (in subject 2), ice-slush was injected onto the renal surface via syringes through the mini-GeiPOINT.

Stone Creation
• Low Viscosity DenMat Precision material (DenMat Inc., CA) was utilized.

Outcomes
• Feasibility of technique (need for conversion to open surgery or any complications) and the in vivo stone model;
• Operative parameters including console operating time, ischemia times, renal surface temperature, and estimated blood loss (EBL);
• Functional outcomes including immediate preoperative and postoperative creatinine.

RESULTS

In the 2 porcine females:
• The procedure could be completed without the need to convert to open surgery, or any complications;
• Firefly aided in precise and clear identification of the anatrophic plane (Figure 2);
• Replica stones could be removed in toto through the anatrophic incision (Figure 3);
• Mean console time was 114 minutes;
• Mean blood loss was 160 cc;
• Warm and cold ischemia times were 36 and 33 minutes, respectively; a renal surface temperature of 15.4 C was achieved with renal cooling (120 cc of ice-slush);
• No difference in pre- and postoperative creatinine values (mean preoperative 1.4 mg/dl vs. mean postoperative 1.3 mg/dl);
• Replica staghorn stones (mean size 5.1 cm) could be reliably created with injection of ~50cc of the DenMat resin (solidifying time 2-3 minutes).

CONCLUSIONS

• We have demonstrated for the first time that use of NIRF image-guidance accurately identifies the renal avascular plane, thus permitting a true anatrophic robotic approach for staghorn stones.
• This pre-clinical study represents the first step in establishment of a novel RANL technique in a patient conscientious manner, in accordance with the recommendations of the IDEAL Collaboration for safe surgical innovation; next step would be careful identification of optimal candidates for this approach to test the feasibility and efficacy in clinical setting.
• Further, we describe a reliable, replicable in vivo stone model which can be utilized to investigate novel surgical modalities for stone disease.