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Original Article

# PRELIMINARY EVALUATION OF HIGH-FREQUENCY JET VENTILATION IN RIRS FROM A TERTIARY CENTER

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## INTRODUCTION AND OBJECTIVES

Retrograde intrarenal surgery (RIRS) with the usage of laser in treating different upper urinary tract conditions in a minimally invasive way has been gaining traction in the last decades. The evolution of endoscopic instruments as well as laser techniques have expanded indications such as the treatment of larger stone burden with RIRS. RIRS is now an effective and safe therapeutic option in the treatment of renal stones, upper tract urothelial carcinoma (UTUC) and ureteropelvic junction obstruction (UPJO).[1] A variety of anesthetic techniques have been used during different urological procedures, including shock wave lithotripsy (SWL), although spontaneous ventilation with a laryngeal mask airway is the most common approach. Renal movements caused by respiration have always made retrograde intrarenal surgery (RIRS) challenging because of the difficulty in treating a moving target. These problems may be more significant in large renal stones and UTUC where precision is essential. The type of anesthesia used during RIRS can influence the outcome of the procedure and may affect the operating time. Different types of anesthesia have been used during RIRS to reduce the renal movement such as general anesthesia (GA) with intraoperative apnea, combined spinal and epidural anesthesia. To date there is no published data on the use of high-frequency jet ventilation (HFJV) during RIRS. HFJV is a high-frequency ventilation mode, widely used in ear nose and throat surgery (ENT). Within urology this technique has been previously reported during SWL and the authors report a reduction of renal movement from 32 mm to 10 mm,[2,3] which resulted in reduced stone movement, treatment time, and shock energy requirements, as well decreasing exposure to X-rays and perinephric trauma. HFJV is not adapted widely in urological practice because of the need of a special ventilator equipment as well as training and experience in the technique. In a pilot study, we evaluated a HFJV ventilatory protocol in endoscopic treatment of renal stones larger than 7 mm.

## MATERIALS AND METHODS

Our hospital is a tertiary center for minimally invasive treatment of liver and renal tumors using microwaves (MW), irreversible electroporation (IRE) and radiofrequency (RF) for tumor ablation. Ablations are ultrasound- or CT-guided and HFJV is used to reduce the movements of the targeted organ to facilitate the puncture. The aim of our study was to evaluate whether the usage of HFJV would reduce renal movement facilitating more precise treatment of renal stones by reducing the operation time and improving the outcomes of RIRS. Inclusion criteria we set were renal stones larger than 7 mm and the exclusion of patients with pulmonary disease. All patients had None-Contrast Computerized Tomography (NCCT) performed preoperatively to evaluate the stone burden.

A urine culture was taken a week prior to surgery, asymptomatic bacteriuria was treated with suitable antibiotics with start 2–3 days before the surgery. In addition to that, all the patients received a single dose gentamicin i.v. perioperatively. Anesthesia management protocol was set up in the following manner: GA had been induced and maintained by total intravenous technique (TIVA) with target-controlled infusion of propofol and remifentanil with muscle relaxation achieved by incremental doses of rocuronium. After completing intubation with the conventional endotracheal (ET) tube, HFJV cannula (LaserJet Catheter, Acutronic Medical Systems AG, Hirzel, Switzerland) was placed with its tip at the end of ET-tube. HFJV was then initiated and continued throughout the procedure (Monsoon HFJV ventilator, Acutronic Medical Systems, AG, 8816 Hirzel, Switzerland). Duration of HFJV and intraoperative $EtCO_2$ were measured before and after the HFJV procedure. $SatO_2$ values as well as eventual postoperative respiratory adverse events were registered for further analysis and discussion. In all cases an access sheath Bi Flex (Rocamed) 10/12 Fr was placed. Irrigation control was managed by using a single chamber Endoflow pump (Rocamed). We used a digital flexible ureteroscope from Storz (Flex XC) and Holmium laser with 2 settings 6hz-1,2 J and 10hz-0,5 J used for stone disintegration and/or dusting. In 12 of the 15 cases a JJ catheter was placed at the end of surgery. The JJ catheter was left for 3–10 days. Stone free rate was evaluated by performing a follow up with NCCT 6 weeks to 3 months after the surgery. All surgical procedures were performed by one of 2 dedicated endourologists.

## RESULTS

Fifteen patients were included in the study, 8 males and 7 females, aged 23–83 years old. The stones varied from 7 cm to 24 mm with a mean diameter of 12 mm and median diameter of 15.5 mm. Four patients had multiple stones (2 stones each). American Society of Anesthesia (ASA) classification ranged from ASA 1 in 3 patients, ASA 2 in seven patients to ASA 3 in five patients. The body-mass index (BMI) ranged from 23–41, for patient's data see Table 1.

Mean duration of HFJV procedure was 52.5 min (35–110), Et $CO_2$ before HFJV – 4.75 % (4.1–5.5) and after HFJV 4.95 % (4.3–6.6) respectively. Neither intraoperative oxygen desaturations nor postoperative

**Table 1** Patient Data

| Patient | Age | Sex | ASA | BMI | Stone | Side | Op time | HU | FU |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 68 | **M** | 2 | 25 | 2(11×9, 10×10) | Left | 76 min | 600 | 0 |
| **2** | 74 | **F** | 3 | 23 | 2(13 mm, 6 mm) | Left | 47 min | 1028 | < 4mm |
| **3** | 67 | **F** | 2 | 23.8 | 13×9 mm | Left | 49 min | 1400 | 0 |
| **4** | 23 | **F** | 1 | 24 | 14×9 mm | Right | 34 min | 1350 | 0 |
| **5** | 70 | **M** | 3 | 26 | 11×10(Calyx) | Right | 62 min | 1328 | < 4mm |
| **6** | 83 | **M** | 3 | 24 | 17×15 mm | Left | 58 min | 1182 | > 4mm |
| **7** | 66 | **F** | 2 | 28 | 9×7 mm | Left | 31 min | 1066 | < 4mm |
| **8** | 68 | **F** | 2 | 27 | 15×9 mm | Left | 39 min | 450 | 0 |
| **9** | 53 | **M** | 1 | 25 | 7 mm | Left | 20 min | 770 | 0 |
| **10** | 74 | **F** | 3 | 41 | 20×10 mm | Left | 90 min | 800 | > 4 mm |
| **11** | 49 | **F** | 1 | 29 | 2(12×10 ,9×9) | Right | 35 min | 1056 | 0 |
| **12** | 45 | **M** | 2 | 34 | 7mm (hoarse shoe) | right | 14 min | 450 | 0 |
| **13** | 67 | **M** | 2 | 25 | 24×15×11 mm | Left | 35 min | 1050 | 0 |
| **14** | 56 | **M** | 2 | 26.85 | 18×13, 15×11 | Left | 30 min | 1030 | > 4 mm |
| **15** | 69 | **M** | 3 | 26.88 | 8mm+ureter 6 mm | Left | 20 min | 1080 | > 4mm |

signs of respiratory impairment were detected in any patient. The laser stone fragmentation time was between 20–102 minutes. Although the renal movements with or without the use of HFJV could not be measured exactly, the movement reduction with HFJV was without doubt noticeable by the surgeon. One of 15 patients developed urinary tract infection (UTI) 3-days postoperatively and was admitted for intravenous treatment. One patient was admitted because of stent migration and the stent was extracted and one patient was admitted because of pain after stent extraction. At the 3-month follow up 8 patients were found to be stone free, 3 had a < 4mm asymptomatic residual stone and 4 had > 4 mm asymptomatic residual stone (one of them had an auxiliary SWL treatment). No preoperative or postoperative pulmonary complications were reported.

## DISCUSSION

High-frequency jet ventilation (HFJV) is a method of lung ventilation described first by Klain and Smith in 1977. The technique involves the intermittent delivery of respiratory gas admixture from a high-pressure nozzle through a small-bore cannula positioned in the airway, followed by passive expiration.[4] The HFJV cannula we use can be placed in the airway either solely, or via a classic endotracheal tube. For better airway control and to minimize the risk of lung aspiration. In our institution we use the latter. The classical indication for the use of HFJV in GA is any ENT surgery where using small-bore cannulas is an attractive alternative ventilation technique when operation field and classical airway management devices are in conflict. Over the last few years the primary field of interest for using HFJV has become the stereotactic minimally invasive ablative surgery, where minimizing the respiratory movements-related abdominal organ motion is crucial for the precision of the surgical procedure. Several reports have been published during the last decade[5–8] that discuss the use of HFJV in a range of oncological procedures. In urology, HFJV has been successfully used in SWL surgery to minimize the numbers of shocks needed.[9] We should be mindful that using HFJV has some potential drawbacks that may include[10]: Intrinsic PEEP (Positive end-expiratory pressure), barotrauma or pneumothorax can occur. However, all these risks can be minimized by safety modalities of modern jet ventilators.[4] In our trial, no hypoxic events or any signs of postoperative respiratory impairment were detected. Our previous experience shows that during HFJV, carbon dioxide ($CO_2$) retention may become challenging. However, in this recent study, we registered an end tidal $CO_2$ ($EtCO_2$) rise only in sporadic cases, which were considered to not to be significant enough to have any clinical relevance. Since the lung ventilation is run in an open system, the $EtCO_2$ control is difficult and can be performed only sequentially. For accurate continuous measurement, transcutaneous $CO_2$ monitoring ($TcCO_2$) is strongly recommended, which recently became a clinical standard in our institution. As an alternative to the lung ventilation protocol chosen for our study, the use of apneic techniques has been reported.[11] The surgical goal of immobilizing target organ is achieved but there is an important limitation to wide implementation of this technique, compared to the HFJV. The time limit for using apneic oxygenation devices is currently set at 20–30 minutes. This limit along with the $CO_2$ retention and following desaturation forces the operators to revert to the conventional tidal-volume ventilation in the latter stages of the treatments.[12] This does not happen while using HFJV. Just like the latter, apneic technique needs a careful oxygen saturation and $CO_2$ tension monitoring with the use of transcutaneous detector. Furthermore, prolonged apnea can attenuate atelectasis formation and late respiratory complications.[13]

From the results of this early report we can confidently recommend the usage of HFJV as described in our study. It can be considered a safe and feasible alternative for the management of RIRS cases. Obviously, it has to be pointed out that the suggested potential of improving surgical outcomes needs further evaluation in the conditions of large sample randomized controlled studies.

## CONCLUSION

Renal movements during RIRS are challenging, especially in cases where precise maneuvers during particular treatment are required. This preliminary report reveals HFJV as a safe, feasible method that can be used in RIRS to significantly enhance the efficacy of the procedure, allowing for more precise maneuvers. The use of HFJV may reduce the operating time and the risk for subsequent UTI. The use of HFJV needs more evaluation in larger studies to assess its impact on outcomes of RIRS.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## ETHICAL APPROVAL

All procedures performed were in accordance with the ethical standards of the institution at which the studies were conducted.

## INFORMED CONSENT STATEMENT

The patients involved consented to the use of their procedural data for the preparation of this manuscript.

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