High-frequency jet ventilation is beneficial during shock wave lithotripsy utilizing a newer unit with a narrower focal zone

Phillip Mucksavage, MD; Wesley A. Mayer, MD;* Jeff E. Mandel, MD;† Keith N. Van Arsdalen, MD**

Abstract

Introduction: High-frequency jet ventilation (HFJV) during shock wave lithotripsy (SWL) has been reported using older lithotripsy units with larger focal zones. We investigated how HFJV affects the clinical parameters of SWL using a newer lithotripsy unit with a smaller focal zone.
Methods: We reviewed all patients who underwent SWL by a single surgeon (KVA) from July 2006 until December 2007 with the Siemens Lithostar Modularis (Siemens AG, Erlangen, Germany). Either HFJV or conventional anesthetic techniques were used based on the anesthesiologists' preference. Preoperative imaging was reviewed for stone size, number and location. Total operating room time, procedure time, number of shocks and total energy delivery were analyzed. Postoperative imaging was reviewed for stone-free rates.
Results: A total of 112 patients underwent SWL with 80 undergoing conventional anesthesia, and 32 with HFJV. Age, body mass index, preoperative stone size and number were not significantly different between the groups. The HFJV group required significantly less total shocks (3358 vs. 3754, $p = 0.0015$) and total energy (115.8 joules vs. 137.2 joules, $p = 0.0015$). Total operating room time, SWL procedure time and postoperative stone-free rates were not significantly different.
Conclusions: Previous studies using older SWL units with larger focal zones have demonstrated that HFJV can be effective in reducing total shocks and total energy. Our data is consistent with these studies, but also shows benefit with newer units that have narrower focal zones.

Can Urol Assoc J 2010;4(5):333-335

Resumé

Introduction : Le recours au jet-ventilation à haute fréquence (JVHF) pendant une lithotritie par ondes de choc (LOC) a été signalé lors d'emploi d'anciens appareils de lithotritie à zones focales larges. Nous avons examiné comment le JVHF influe sur les paramètres cliniques de la LOC lors de l'emploi d'un nouvel appareil de lithotritie avec zones focales étroites.
Méthodologie : Nous avons passé en revue le dossier de tous les patients qui ont subi une LOC réalisée par le même chirurgien (KVA) entre juillet 2006 et décembre 2007 à l'aide du Lithostar Modularis de Siemens (Siemens S.A., Erlangen, Allemagne). Le JVHF ou une technique classique d'anesthésie ont été utilisés, selon la préférence des anesthésistes. Les images obtenues avant l'intervention ont été analysées afin de déterminer la taille, le nombre et l'emplacement des calculs. Le temps total en salle d'opération, la durée de l'intervention, le nombre d'ondes de choc et la quantité totale d'énergie émise ont été analysés. Le taux d'absence de calculs après l'intervention a été obtenu à l'aide d'images prises après l'intervention.
Résultats : Au total, 112 patients ont subi une LOC; de ce nombre, 80 ont reçu une anesthésie classique, et 32, une anesthésie par JVHF. L'âge, l'indice de masse corporelle, la taille et le nombre des calculs avant l'intervention n'étaient pas significativement différents d'un groupe à l'autre. Le groupe sous JVHF a requis un nombre total significativement inférieur d'ondes de choc (3358 contre 3754, p = 0,0015) et une quantité significativement moindre d'énergie (115,8 joules contre 137,2 joules, p = 0,0015). Le temps total en salle d'opération, la durée de l'intervention et le taux d'absence de calculs après l'intervention étaient sensiblement les mêmes dans les deux groupes.
Conclusions : Des études antérieures utilisant des appareils plus anciens de LOC avec des zones focales larges ont montré que le JVHF peut être efficace pour réduire le nombre total d'ondes de choc et la quantité totale d'énergie requise. Les données de notre étude concordent avec celles de ces études, mais montrent aussi les avantages de recourir à des zones focales plus étroites.

Introduction

The Dornier HM3 lithotripter (Dornier Medizintechnik GmbH, Germering, Germany) was first introduced to the United States in the early 1980s.[1] Since then, shock wave lithotripsy (SWL) has revolutionized the treatment of stone disease.[2,3] Over the past 20 years, there have been ongoing efforts to improve lithotripter equipment; since the Dornier HM3, there have been over 40 lithotripters developed.[4,5] Newer lithotripters use narrower focal zones allowing for the theoretical benefits of decrease pain and collateral trauma.[4,7] These theoretical benefits, however, may have come at the expense of decreased efficacy, perhaps because targeting is more difficult with a smaller focal zone.[4,5]

Various anesthetic techniques can be used during SWL. Many of these anesthetic techniques can result in significant respiratory variability resulting in the movement of the stone out of the focal zone. Early studies with the Dornier HM3 demonstrated that using high-frequency jet ventilation (HFJV) during SWL decreased stone movement and the number of required shocks as compared to conventional mechanical ventilation (CMV);[6] however, the use of HFJV during SWL with newer lithotripter units is not well-known. We sought to examine the differences in stone outcomes, number of shocks and amount of energy delivered during SWL with a newer lithotripter depending on the type of anesthesia delivered.

Methods and materials

A retrospective review was performed on the records of every patient presenting for SWL performed by a single urologist (KVA) from July 2006 to December 2007. All procedures were performed with the Siemens Lithostar Modularis (Siemens AG, Erlangen, Germany). All preoperative computed tomography (CT) scans and intravenous pyleograms (IVP) were reviewed for stone size and location (lower pole, ureteral). All patients underwent a plain film of the abdomen (kidney/ureter/bladder [KUB]) on the day of the procedure to confirm stone presence and location. Operating room records were reviewed to determine total time in the operating room, total procedure time, total number of shocks, total amount of energy delivered and the type of anesthesia delivered. Time in the post-anesthesia care unit (PACU) was also calculated as the time the patient arrived in the PACU until the time the patient was discharged. Postoperative films including limited IVP, KUB or CT scan were obtained at least 6 weeks after SWL. A patient was considered "stone free" if there was no evidence of stone disease seen on the postoperative imaging obtained 6 weeks after the procedure.

The use of HFJV was determined at the discretion of the attending anesthesiologist. When HFJV was employed, anesthesia was induced and maintained with total intravenous anesthesia using propofol and remifentanil. High-frequency jet ventilation is instituted with a Monsoon ventilator (Acutronic Medical System, Fabrik im Schiffli, Switzerland). An endotracheal tube or Laryngeal mask airway is placed, and the jet ventilator connected to the tube with a luer fitting elbow (Part #5600EL, Vital Signs, Totowa, NJ). End-tidal carbon dioxide is periodically assessed by stopping HFJV and by giving several tidal breaths.

All data was analyzed with Student T-test, Fisher's exact tests or Mann Whitney U test, depending on the characteristics of the data. All analysis was performed with Stata 9 (Stata Corporation, College Station, TX).

Table 1. Patient characteristics

	CMV (n = 81)	HFJV (n = 32)	*p* value
Age	51.7	49.8	0.596*
BMI	28.3	27.4	0.486*
No. stones (%)			
1	90.1%	84.4%	
2	7.41%	12.5%	
3	2.47%	3.13%	0.570**
Ureteral stones	8 (9.88%)	9 (28.1%)	0.021**
Lower pole stones	28 (36.4%)	8(25.8%)	0.378**
Stones >1 cm	38 (48.1%)	17 (53.1%)	0.679**
Repeat procedures	18 (28%)	4 (14%)	0.188**

CMV = conventional mechanical ventilation; HFJV = high-frequency jet ventilation; BMI = body mass index. *Student T-test; **Fisher's exact test.

Table 2. Outcomes for all shock wave lithotripsy events

	CMV (n = 81)	HFJV (n = 32)	*p* value
Total no. shocks	3754	3358	0.007+
Total energy, joules	137.2	115.9	0.005+
OR time, min	91.6	100.2	0.650*
Procedure time, min	54.2	50.1	0.407*
Stone-free rates	34.3%	51.8%	0.168**

CMV = conventional mechanical ventilation; HFJV = high-frequency jet ventilation; OR = operating room. *Student T-test; **Fisher's exact test; +Mann Whitney U test.

Results

The demographics of the 113 SWL procedures are represented in Table 1. Patients receiving HFJV compared to CMV were no different in terms of age, body mass index, lower pole stones, stones size greater than 1 cm and number of stones.

When all SWL events were compared for outcomes, total number of shocks (3754 vs. 3358, $p = 0.007$) and total energy delivered (137.2 joules vs. 115.9 joules, $p = 0.005$) were significantly less in the group undergoing HFJV compared to the group undergoing CMV. Total time spent in the operating room (91.6 minutes vs. 100.2 minutes, $p = 0.65$) and total procedure time (54.2 minutes vs. 50.1 minutes, $p = 0.407$) were not different. Although overall stone-free rates were higher in the HFJV (51.8% vs. 34.3%) this difference was not significant ($p = 0.168$) (Table 2).

Postoperatively, patients undergoing HFJV spent slightly less time in the postoperative recovery area, but this was not significantly different from the CMV (95.8 minutes vs. 113.8 minutes, $p = 0.10$) No patients in either group were directly admitted to the hospital after the procedure for pain issues. One patient with severe chronic obstructive pulmonary disease in the CMV group was admitted for observation secondary to respiratory compromise. In this series, there was only 1 readmission for steinstrasse in the CMV group and no cases of pyleonephritis, sepsis or perinephric trauma (as assessed by postoperative image review at 6 weeks) in either group.

Discussion

Warner and colleagues in 1988 were the first to investigate the potential benefits of HFJV for SWL.[6] They found that mean stone movement and mean total shocks were significantly decreased during HFJV compared with CMV. Thus, HFJV may have a theoretical advantage of decreased shock energy requirements, decreased operating room time, less pain, less perinephric trauma and even increased stone-free rates. However, these studies employed the Dornier® HM3 lithotripter. Our intention was to investigate the effects of HFJV during SWL using a newer generation lithotripter with a smaller focal zone.

We found that the group undergoing HFJV during SWL with the Seimens® Lithostar Modularis, a third-generation lithotripsy machine, required significantly less total shocks (3754 vs. 3358, $p = 0.007$) and total energy delivered (137.2 joules vs. 115.9 joules, $p = 0.005$) compared with the group undergoing conventional anesthetic techniques. These results are similar to the finding of Cormack and colleagues, who employed HFJV and CMV in 91 patients using a modern lithotripsy device; they also found that patient undergoing HFJV required less total number of shocks per treatment.[7]

Given that the HFJV group required less total shocks, one might have expected to find the group undergoing HFJV would enjoy decreased operating room time. However, there was no difference in total procedure time or total operating room time between the 2 groups. One explanation for this observation is that HFJV requires total intravenous anesthesia, which can be more technically demanding as compared to general anesthesia with inhalational agents.

In 1988, Whelan and colleagues found significantly greater fragmentation of material using an experimental HFJV model.[8] Although our series showed a trend towards greater stone-free rates in the HFJV group (51.8% vs. 34.3%), this result was not significant ($p = 0.168$). This may be due to the small numbers of patients reviewed or the fact that our patients were heterogeneous in terms of their preoperative stone burden and stone location. Also, this series includes a number of patients who underwent retreatment.

Our study has several weaknesses, including its retrospective design. Our series included a relatively small number of patients undergoing HFJV. Also, the group undergoing conventional anesthetic techniques was heterogeneous and included both spontaneous and mechanical ventilation. Finally, stone-free rates were determined after review of the available postoperative imaging obtained. Most of these images were limited IVP, however, CT scans and plain abdominal films were also used to determine stone-free rates. Prospective randomized trials would be helpful in delineating the real benefits of HFJV during SWL with newer lithotripsy units.

Conclusion

Early studies Dornier® HM3 lithotripter demonstrated HFJV can be effective in reducing total shocks and movement of stone during SWL. This study is consistent with these studies and demonstrates HFJV can be effective in reducing the total number of shocks and the total energy used during SWL with a newer lithotripter with a smaller focal zone. Decreased total energy may lead to decreased postoperative pain. However, total SWL time, total operative room time and stone-free rates were not different.

[*]Division of Urology, University of Pennsylvania Health System, Philadelphia, PA; [†]Department of Anesthesiology and Critical Care, University of Pennsylvania Health System, Philadelphia, PA

Competing interests: None declared.

This paper has been peer-reviewed.

References

1. Chaussy C, Schmiedt E, Jocham D, et al. First clinical experience with extracorporeally induced destruction of kidney stones by shock waves. *J Urol* 1982;127:417-20.
2. Drach GW, Dretler S, Fair W, et al. Report of the United States cooperative study of extracorporeal shock wave lithotripsy. *J Urol* 1986;135:1127-33.
3. Lingeman JE, Newman D, Mertz J, et al. Extracorporeal shock wave lithotripsy: the Methodist Hospital of Indiana experience. *J Urol* 1986;135:1134-7.
4. Miller NL, Lingeman JE. Treatment of kidney stones: current lithotripsy devices are proving less effective in some cases. *Nat Clin Pract Urol* 2006;3:236-7.
5. Argyropoulos AN, Tolley, David A. Optimizing shock wave lithotripsy in the 21st century. *Eur Uol* 2007;52:344-52.
6. Warner MA, Warner ME, Buck CF, et al. Clinical efficacy of high frequency jet ventilation during extracorporeal shock wave lithotripsy of renal and ureteral calculi: a comparison with conventional mechanical ventilation. *J Urol* 1988;139:486-7.
7. Cormack JR, Hui R, Olive D, et al. Comparison of two ventilation techniques during general anesthesia for extracorporeal shock wave lithotripsy: high-frequency jet ventilation versus spontaneous ventilation with a laryngeal mask airway. *Urology* 2007;70:7-10.
8. Whelan JP, Gravenstein N, Welch JL, et al. Simulation of ventilatory-induced stone movement and its effect on stone fracture during extracorporeal shock wave lithotripsy. *J Urol* 1988;140:405-7.

Correspondence: Dr. Phillip Mucksavage, Division of Urology, University of Pennsylvania School of Medicine, 9 Penn Tower, 34th and Civic Center Blvd., Philadelphia, PA 19104; fax: 215-662-3955; phillip.mucksavage@uphs.upenn.edu