Anesthesiologist-controlled *versus* patient-controlled propofol sedation for shockwave lithotripsy

[La sédation au propofol contrôlée par l'anesthésiologiste ou le patient pour la lithotripsie par ondes de choc]

Jamal A. Alhashemi MBBS MSC FRCPC FCCP, Abdullah M. Kaki MBBS FRCPC

Purpose: To compare anesthesiologist-controlled sedation (ACS) with patient-controlled sedation (PCS), with respect to propofol requirements, sedation, and recovery, in patients undergoing extracorporeal shockwave lithotripsy for urinary calculi.

Methods: Sixty-four patients were randomized, in this double-blind study, to receive propofol sedation according to one of two regimens: infusion of $200 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for ten minutes reduced thereafter to $50\text{--}150 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ titrated by an anesthesiologist, according to patient response (group ACS), or propofol administered by patient-controlled analgesia (bolus dose $300 \mu\text{g}\cdot\text{kg}^{-1}$, lockout interval three minutes, no basal infusion), (group PCS). All patients received midazolam $10 \mu\text{g}\cdot\text{kg}^{-1}$ iv and fentanyl $1 \mu\text{g}\cdot\text{kg}^{-1}$ iv preoperatively, followed by fentanyl infused at a rate of $0.5 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{hr}^{-1}$ throughout the procedure. Sedation and analgesia were assessed using the A-line ARX index and visual analogue scale, respectively. Psychomotor recovery and readiness for recovery room discharge were assessed using the Trieger dot test and postanesthesia discharge score, respectively. Patient satisfaction was assessed on a seven-point scale (1–7).

Results: In comparison to group PCS, patients in group ACS received more propofol (398 ± 162 mg vs 199 ± 68 mg, $P < 0.001$), were more sedated (A-line ARX index: 35 ± 16 vs 73 ± 16 , $P < 0.001$), experienced less pain (visual analogue scale: 0 ± 0 vs 3 ± 1 , $P < 0.001$), and were more satisfied (median [Q1, Q3]: 7 [7, 7] vs 6 [6, 7], $P < 0.001$). In contrast, patients in group PCS had faster psychomotor recovery (Trieger dot test median [Q1, Q3]: 8 [4, 16] vs 16 [12, 26] dots missed, $P = 0.002$) and achieved postanesthesia discharge score ≥ 9 earlier (median [Q1, Q3]: 40 [35, 60] vs 88 [75, 100] min, $P < 0.001$) compared with group ACS.

Conclusion: In comparison to PCS for patients undergoing extracorporeal shockwave lithotripsy, propofol/fentanyl ACS

is associated with increased propofol administration, deeper sedation levels, and greater patient comfort. However, ACS is associated with slower recovery and a longer time to meet discharge criteria, when compared to PCS.

Objectif : Comparer la sédation contrôlée par l'anesthésiologiste (SCA) à la sédation contrôlée par le patient (SCP) quant aux demandes de propofol, à la sédation et à la récupération chez des patients devant subir une lithotripsie à ondes de choc électrohydraulique pour urolithiase.

Méthode : Soixante-quatre patients, répartis au hasard pour une étude à double insu, ont reçu : soit une sédation par une perfusion de propofol de $200 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ pendant dix minutes, réduite ensuite à $50\text{--}150 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ ajustée par un anesthésiologiste en fonction de la réaction du patient (groupe SCA), soit du propofol en analgésie autocontrôlée (bolus de $300 \mu\text{g}\cdot\text{kg}^{-1}$, période réfractaire de trois minutes, sans perfusion initiale), (groupe SCP). Avant l'opération, tous les patients ont reçu $10 \mu\text{g}\cdot\text{kg}^{-1}$ de midazolam iv et $1 \mu\text{g}\cdot\text{kg}^{-1}$ de fentanyl iv, puis une perfusion de fentanyl à $0,5 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{h}^{-1}$ tout au long de l'intervention. La sédation et l'analgésie ont été évaluées par l'index A-line ARX et l'échelle visuelle analogique (EVA), respectivement. La récupération psychomotrice et l'état permettant de quitter la salle de réveil ont été évalués par le Trieger Dot Test et les critères de sortie de la salle de réveil, respectivement. La satisfaction du patient a été évaluée sur une échelle de sept points (1–7).

Résultats : Comparés aux patients du groupe SCP, ceux du groupe SCA ont reçu plus de propofol (398 ± 162 mg vs 199 ± 68 mg, $P < 0,001$), et plus de sédatifs (index A-line ARX : 35 ± 16 vs 73 ± 16 , $P < 0,001$), éprouvé moins de douleur (EVA : 0 ± 0 vs 3 ± 1 , $P < 0,001$) et ont été plus satisfaits (médiane [Q1, Q3] : 7 [7, 7] vs 6 [6, 7], $P < 0,001$). Par ailleurs, les patients du groupe SCP ont connu une récupération psychomotrice plus rapide (mé-

From the Department of Anesthesia and Critical Care, King Abdulaziz University, King Abdulaziz University Hospital, Jeddah, Saudi Arabia.

Address correspondence to: Dr. Jamal A. Alhashemi, Department of Anesthesia and Critical Care, King Abdulaziz University Hospital, P.O. Box 31648, Jeddah 21418, Saudi Arabia. Fax: +966 2 6408015; E-mail: jalhashemi@kau.edu.sa

Accepted for publication December 11, 2005.

Revision accepted January 5, 2005.

The study was supported in part by Departmental Research Fund. Competing Interests: None declared.

diane du Trieger dot test [Q1, Q3] : 8 [4, 16] vs 16 [12, 26] points manqués, $P = 0,002$) et ont atteint les critères de sortie de la salle de réveil ≥ 9 plus tôt (médiane [Q1, Q3] : 40 [35, 60] vs 88 [75, 100] min, $P < 0,001$).

Conclusion : Comparée à la SCP pour une lithotripsie à ondes de choc électrohydraulique, la SCA au propofol/fentanyl est associée à une plus grande consommation de propofol, à des niveaux de sédation plus profonds et à un plus grand confort du patient. Mais la SCA, comparée à la SCP, retarde la récupération et prolonge le temps en salle de réveil.

TRADITIONALLY, anesthesiologists control the titration of sedation and analgesia for monitored anesthesia care procedures. Some ambulatory procedures, such as extracorporeal shockwave lithotripsy (ESWL), are more painful than others, and require relatively deeper levels of sedation to achieve patient comfort, and meet surgical requirements of a still, calm patient. Recently, patient-controlled sedation (PCS) has emerged as an alternative sedation option for this patient population and procedure.¹⁻³ However, most studies examining PCS evaluated predominantly opioid-based techniques, which are associated with nausea and vomiting, and an increased risk of respiratory depression, either during or after the procedure.⁴ In contrast, propofol-based sedation regimens may provide effective sedation without delaying hospital discharge⁵, and are associated with a lower incidence of postoperative nausea and vomiting.^{2,5}

It is not currently known whether PCS with propofol may provide a safe and effective alternative to anesthesiologist-controlled sedation (ACS). We therefore undertook a randomized, double-blind study to evaluate the efficacy of patient-controlled propofol sedation compared to anesthesiologist-controlled propofol sedation in patients undergoing ESWL procedures for ablation of urinary tract calculi. We hypothesized that PCS sedation during ESWL would be associated with lower propofol requirements, while maintaining comparable levels of patient sedation and analgesia, compared with ACS.

Methods

After Institutional Ethics Committee approval, 64 ASA physical class I–II patients gave written informed consent to participate in this randomized, double-blind, clinical trial. Patients were included in the trial if they were 18 to 80 yr of age, had renal or ureteric calculi, and were scheduled for ESWL. Patients were

excluded from the study if they had any of the following: (a) history of chronic use of analgesic and/or sedative agents; (b) history of alcohol abuse; (c) a language barrier or mental disorder that would prevent them from understanding how to operate a patient-controlled analgesia machine; or (d) allergy to any of the study medications. Using a computer-generated randomization schedule, patients were randomized to one of two groups; anesthesiologist-controlled (group ACS) or patient-controlled (group PCS) propofol sedation. Group ACS patients received their sedation by the same anesthesiologist throughout the study to eliminate inter-physician variability. This anesthesiologist was not involved with the design of the study. All data were recorded by a qualified, independent observer who was blinded to group assignment.

Prior to the ESWL procedure, each patient received appropriately detailed instructions regarding proper use of a patient-controlled analgesia device (IVAC PCAM™, Alaris Medical Systems, Hampshire, UK). Specifically, patients were asked to “push the button” in response to anxiety, and/or the desire to move. After being positioned on the lithotripsy table, an electrocardiogram, a non-invasive blood pressure, and a pulse oximeter (Dinamap™ Plus, Critikon Inc., Tampa, FL, USA) were applied to each patient. Supplemental oxygen at a flow rate of 2 L·min⁻¹ was administered via nasal cannulae.

After recording baseline measurements (see below), all patients received midazolam 10 µg·kg⁻¹, premixed with fentanyl 1 µg·kg⁻¹ *iv*. This was followed by a continuous infusion of fentanyl 0.5 µg·kg⁻¹·hr⁻¹ throughout the case. Patients in group ACS received propofol infused at 200 µg·kg⁻¹·min⁻¹ for ten minutes, followed by a variable rate infusion between 50–150 µg·kg⁻¹·min⁻¹, titrated to patient comfort and lack of movement in response to ESWL, and stopped at the end of the ESWL session. Concurrently, patients were given the push button of a patient-controlled analgesia machine that had the same settings as the machine used in group PCS (see below), and 10% intralipid was used to maintain blinding. In contrast, group PCS patients received propofol via the patient-controlled analgesia machine with the following settings: propofol bolus dose 300 µg·kg⁻¹ *iv*, lockout interval three minutes, and no basal infusion. Concurrently, the blinded anesthesiologist infused 10% intralipid using the same protocol and infusion pump settings that were used in group ACS, and the infusion was terminated at the end of the session. Extracorporeal shockwave lithotripsy began five minutes after administration of the midazolam/fentanyl bolus in both study groups. The urologist, who was also blinded to

patient's group assignment, titrated the shock wave intensity based on patient's tolerance of the procedure. Rescue analgesia was provided by fentanyl 50 µg *iv prn* in response to patient request for additional analgesia; or if the surgeon had to temporarily withhold the shock waves and/or decrease ESWL intensity to $\leq 40\%$ of initial settings as a result of patient movement secondary to pain.

Sedation levels were recorded using the A-line ARX index (AAI),⁶ as determined by the A-line™ monitor (Danmeter A/S, Odense, Denmark). This device extracts the mid-latency auditory evoked potentials from the electroencephalographic signal of the patient using an autoregressive model with an exogenous input (ARX) adaptive method. The method enables extraction of the auditory evoked potentials within 15–25 sweeps, needing only two to six seconds; the AAI is then calculated from this auditory evoked potentials wave. The anesthesiologist responsible for propofol or intralipid titration remained blinded to the AAI readings throughout the trial.

Heart rate, mean arterial pressure, oxygen saturation, and AAI were recorded at baseline and every five minutes thereafter until the end of the procedure. Pain was assessed at baseline, and every 15 min during ESWL using a visual analogue scale (VAS) ruler with two anchor points; 0 being no pain, and 10 being the worst pain the patient had ever experienced. The VAS score was considered to be 0 if the patient was asleep at the time of assessment, which was determined by a lack of response to a gentle call of the patient's name by the blinded observer. No attempts were made to wake up those who were asleep to determine their VAS score. Upon arrival in the recovery area, patients were asked to rate their satisfaction with their intraoperative sedation and analgesia, each on a seven-point scale;⁷ 1 being extremely dissatisfied, and 7 being extremely satisfied. The urologist, also blinded to group allocation, was asked to rate his satisfaction with the patient's tolerance of ESWL using the same scale. Observer's assessment of alertness and sedation scale⁸ and the Trieger dot test⁹ were performed at baseline, and then on admission to the postanesthesia care unit (PACU) and every 30 min thereafter until discharge from PACU. In addition, the postanesthesia discharge score (PADS)¹⁰ was assessed every 30 min after the procedure, and patients were deemed ready for PACU discharge when their PADS score was ≥ 9 . All adverse events including, but not limited to, respiratory depression (defined as a respiratory rate ≤ 10 breaths·min⁻¹) or any episode of oxygen desaturation (oxygen saturation $< 92\%$) were recorded.

TABLE I Baseline characteristics

Characteristic	Group ACS (n = 32)	Group PCS (n = 32)
Age (yr)	45 ± 11	41 ± 10
Weight (kg)	75.5 ± 14.2	80.9 ± 15.2
Height (cm)	163 ± 5	163 ± 8
Male/female	28 / 4	25 / 7
ASA physical class (I/II)	22 / 10	29 / 3
Type of stone (renal/ureteric)	31 / 1	23 / 9
Midazolam (mg)	0.75 ± 0.13	0.81 ± 0.15
Session duration (min)	52 ± 14*	45 ± 10

ACS = anesthesiologist-controlled sedation; PCS = patient-controlled sedation. Data presented as mean ± standard deviation or absolute numbers. * $P = 0.018$, compared with group PCS.

Statistical analysis

Based on a two-sided α of 0.05, a power of 90%, and a population variance of (122)² mg, 32 patients per group were required to detect a difference of 100 mg in the cumulative amount of propofol administered. All analyses were done on an intention-to-treat basis. The cumulative doses of propofol and fentanyl were compared using regression analyses, with duration of drug administration included as a covariate in all models to adjust for the potential confounding effect of time on outcome variables. Sedation and VAS scores, heart rate, and mean arterial pressure were compared by repeated measures analysis of variance. Patient and surgeon satisfaction scores, time to achieve a PADS score ≥ 9 , observer's assessment of alertness and sedation scores, and Trieger dot test scores were analyzed using Mann-Whitney rank sum test. All statistical procedures were performed using SPSS® statistical software (SPSS Inc., Chicago, IL, USA), version 13.0 for Windows®. Results throughout the text, tables, and figures are presented as mean ± standard deviation unless otherwise indicated, and statistical significance was defined as $P < 0.05$.

Results

Seventy consecutive patients scheduled for ESWL were screened for inclusion in the trial, but only 64 agreed to participate. These 64 patients were randomized, and completed the study without protocol violations. All patients were analyzed for primary and secondary outcomes in the group to which they were randomized. Baseline characteristics were similar between study groups (Table I). The ESWL procedure was seven minutes longer in group ACS compared with group PCS ($P = 0.018$). During ESWL, group ACS patients had deeper levels of sedation overall, as indicated by their lower AAI scores ($P < 0.05$, Figure 1, panel A),

FIGURE 1 A-line ARX index (AAI), (panel A), and visual analogue scale (VAS) scores (panel B) during the course of the lithotripsy. ACS = anesthesiologist-controlled sedation; PCS = patient-controlled sedation. * $P < 0.05$, compared with group PCS.

and had lower VAS scores ($P < 0.05$, Figure 1, panel B) when compared with those in group PCS. However, there were no differences at corresponding times with respect to mean arterial pressure or heart rate between groups (Figure 2, panels A and B). After adjusting for the modest difference in duration of procedure, patients in both study groups received similar cumulative amounts of fentanyl ($P = 0.515$), however, group ACS patients received cumulatively more propofol than did those in group PCS ($P < 0.001$), (Table II). The intensity of delivered shock waves was 20% higher, on average, in group ACS ($P < 0.001$), although, the number of shock waves delivered was similar in both study groups ($P = 0.206$), (Table II). According to the Trieger dot test, psychomotor evidence of recovery was faster in group PCS. However, within 60 min

FIGURE 2 Heart rate (panel A), and mean arterial pressure (panel B) during the course of lithotripsy. ACS = anesthesiologist-controlled sedation; PCS = patient-controlled sedation. Mean values were similar between groups at corresponding times.

of patients' arrival in the PACU, differences between study groups with regards to observer's assessment of alertness and sedation scores and the number of dots missed on the Trieger test were no longer distinguishable (Table III). Based upon median times to achieving PADS score of ≥ 9 , patients in group PCS were ready for PACU discharge 48 min earlier than patients in group ACS ($P < 0.001$). Satisfaction scores were higher amongst patients in group ACS compared with those in group PCS ($P < 0.001$), (Table III). Similarly, surgeon's satisfaction with sedation and analgesia was higher in group ACS ($P = 0.015$). No patient in either study group required rescue analgesia, and there was no evidence of respiratory depression, oxygen desaturation, or other adverse events. No patient required admission to hospital after ESWL. Only one patient in

TABLE II Outcome data

Variable	Group ACS (n = 32)	Group PCS (n = 32)	P value	95% CI ACS-PCS
Total fentanyl ^a (µg)	107 ± 29	111 ± 22	0.515	(-17, 9)
Total propofol ^a (mg)	398 ± 162	199 ± 68	< 0.001	(143, 253)
Shock waves intensity (%)	100 (100, 100)	80 (72.5, 85)	< 0.001	(15, 20)
Shock waves ×1000/patient (n)	3.7 (2.5, 4.6)	3.0 (2.5, 3.7)	0.206	(-0.1, 1.0)
<i>Patient satisfaction with</i>				
Sedation	7 (7, 7)	6 (6, 7)	< 0.001	(0, 1)
Analgesia	7 (7, 7)	6 (5, 7)	< 0.001	(1, 2)
Surgeon satisfaction	7 (6, 7)	6 (6, 7)	0.015	(0, 1)

ACS = anesthesiologist-controlled sedation; PCS = patient-controlled sedation; CI = confidence interval for difference between ACS-PCS. Data presented as mean ± standard deviation or median (25th, 75th centile). ^aAdjusted for session duration.

TABLE III Recovery characteristics

Variable	Group ACS (n = 32)	Group PCS (n = 32)	P value
OAA/S score			
Baseline	5 (5, 5)	5 (5, 5)	*
Immediate recovery	4 (4, 4)	5 (5, 5)	< 0.001
30 min in recovery	4 (4, 5)	5 (5, 5)	< 0.001
60 min in recovery	5 (5, 5)	5 (5, 5)	0.305
<i>Trieger's dot test (dots missed)</i>			
Baseline	3 (1, 6)	2 (1, 5)	0.615
Immediate recovery	16 (12, 26)	8 (4, 16)	0.002
30 min in recovery	6 (3, 12)	4 (1, 8)	0.042
60 min in recovery	4 (2, 8)	4 (1, 9)	0.804
PADS score ≥ 9 (min)	88 (75, 100)	40 (35, 60)	< 0.001

ACS = anesthesiologist-controlled sedation; PCS = patient-controlled sedation; OAA/S = observer's assessment of alertness and sedation; PADS = postanesthesia discharge score. Data presented as median (25th, 75th centile). *P value could not be calculated.

group ACS experienced nausea and vomiting, which was treated with a single dose of metoclopramide.

Discussion

Traditionally, during monitored anesthesia care procedures, the level of sedation is adjusted at the discretion of the anesthesiologist, according to perceived patient requirements. Recently, however, it has been suggested that PCS may be equally effective.¹¹ This randomized, double-blind study demonstrated that ACS for ESWL is associated with better pain control and higher patient satisfaction compared with PCS. The higher patient satisfaction and deeper levels of sedation were, however, achieved at the expense of higher drug utilization and delayed readiness for discharge from the recovery room.

The longer duration of the ESWL procedure and the higher shock wave intensity attained in patients in the ACS group may reflect the deeper levels of sedation and improved patient comfort in this group. After adjusting for the potential effect of session duration, we observed that the anesthesiologist administered

almost twice the cumulative amount of propofol compared to patients who self-administered their propofol for the same procedure, using a patient-controlled analgesia device. As the anesthesiologist was blinded to the A-line™ readings, these findings document the potential to sedate beyond patient requirements. Kortis *et al.*¹² recently demonstrated that patient-controlled analgesia is associated with a 31% reduction in alfentanil administration when compared with physician-controlled analgesia amongst patients undergoing ESWL.¹² In our study, it is unlikely that differences were due to the fact that patients in the PCS group were unable to augment their sedation. The settings on the PCS device allowed patients to receive up to 360 mg of propofol. In contrast, the increased amount of propofol administered to group ACS patients was unlikely to have resulted from protocol constraints of a minimum infusion rate of propofol (50 µg·kg⁻¹·min⁻¹). There were no clinical indications to titrate the infusion rate below this setting, and in fact, most patients required maintenance propofol infusions at nearly twice these rates.

The absence of pain in group ACS patients was due to the fact that patients were asleep (due to heavy sedation) at the time of their pain assessment, and their VAS scores were thus considered to be 0. Since patients in both groups received similar amounts of fentanyl, the sedation level achieved in group ACS was likely responsible for the observed high patient satisfaction scores. In keeping with these results are the findings of Joo *et al.*² who demonstrated that the sedative effects of propofol increase patient comfort levels and result in better satisfaction amongst patients undergoing ESWL.² Nevertheless, the clinical importance of the small difference in satisfaction scores between groups is relatively minor.

Evidence of earlier psychomotor recovery among patients in group PCS was likely due to the decreased use of propofol and the consequent higher sedation scores during the procedure. This may also explain, in part, the earlier readiness for discharge amongst patients in this group. Similar findings have been reported by Bright *et al.*¹¹ when PCS was compared with traditional sedation amongst patients undergoing colonoscopy. However, a limitation of their study was the confounding factor attributable to non-standardization of the drugs used for sedation. In contrast, patients in both groups of the current study received the same drugs, and were treated identically except for the method of propofol administration. Accordingly, observed differences in times to readiness for discharge are most likely attributable to differences in the amounts of propofol used, and the levels of sedation achieved during the procedure, both of which were a function of the method of drug administration. In contrast, Joo *et al.*² reported shorter times to readiness for discharge when PCS was used for ESWL. The discrepancy between their results and ours is most likely attributable to different pharmacokinetic properties and dosages of drugs used for sedation. Remifentanyl and a small fixed doses of propofol were used in Joo *et al.*'s study² whereas fentanyl and larger doses of propofol were used in the current study.

As far as adverse effects are concerned, other investigators have reported a 52% incidence of apnea > 20 sec and a 14% incidence of episodes of desaturation to < 90% amongst patients who have received a remifentanyl/propofol combination using PCS.² These adverse events, however, were not observed in the current study, and the lack thereof could be attributed to the institution of a three-minute lockout interval in group PCS, and to the anesthesiologist's titration of propofol in group ACS. Furthermore, the virtual lack of nausea and vomiting in this study was likely due to the anti-emetic effects of propofol which has been previously reported by others.⁵

Study limitations

One limitation of the current study was the administration of fentanyl as a continuous infusion instead of on-demand boluses. The latter, however, would have confused patients who would have required two patient-controlled analgesia machines to operate; one for fentanyl and one for propofol or as dummy (to maintain blinding), since mixing the two drugs would have made it impossible to differentiate sedative from analgesic requirements. Another possible limitation was the administration of propofol to group ACS patients using a variable-rate infusion as opposed to a target-controlled infusion. The latter has been demonstrated to result in more rapid recovery and earlier discharge from recovery room compared with standard propofol anesthesia;¹³ however, the higher costs associated with target-controlled anesthesia¹³ and the need for special equipment for its administration precluded its use in the current study.

In conclusion, ACS with variable-rate infusion of propofol and constant infusion of fentanyl was associated with a deeper level of sedation and modestly greater patient satisfaction during ESWL, compared with PCS using propofol patient-controlled analgesia and fentanyl infusion. Despite modestly higher patient satisfaction scores with ACS, overall scores are clinically acceptable with PCS. Patient-controlled sedation for ESWL may be an effective option for sedation that is associated with more rapid early recovery and earlier readiness for PACU discharge.

Acknowledgements

The authors acknowledge the help of Dr. Haifa M. Al-Gethami from the Department of Anesthesia and Critical Care, the support of Dr. Abdulmalik Al-Tayeb and Prof. Hisham Mosli from the Department of Urology, and the assistance of Mr. Haitham Abdulmajeed in data collection.

References

- 1 Chin CM, Tay KP, Ng FC, Lim PH, Chng HC. Use of patient-controlled analgesia in extracorporeal shock-wave lithotripsy. *Br J Urol* 1997; 79: 848–51.
- 2 Joo HS, Perks WJ, Kataoka MT, Errett L, Pace K, Honey RJ. A comparison of patient-controlled sedation using either remifentanyl or remifentanyl-propofol for shock wave lithotripsy. *Anesth Analg* 2001; 93: 1227–32.
- 3 Alhashemi JA, Kaki AM. Dexmedetomidine in combination with morphine PCA provides superior analgesia for shockwave lithotripsy. *Can J Anesth* 2004; 51: 342–7.
- 4 Beloeil H, Corsia G, Coriat P, Riou B. Remifentanyl compared with sufentanil during extra-corporeal shock

- wave lithotripsy with spontaneous ventilation: a double-blind, randomized study. *Br J Anaesth* 2002; 89: 567–70.
- 5 *Burmeister MA, Brauer P, Wintruff M, Graefen M, Blanc I, Standl TG.* A comparison of anaesthetic techniques for shock wave lithotripsy: the use of a remifentanyl infusion alone compared to intermittent fentanyl boluses combined with a low dose propofol infusion. *Anaesthesia* 2002; 57: 877–81.
 - 6 *Ge SJ, Zhuang XL, Wang YT, Wang ZD, Li HT.* Changes in the rapidly extracted auditory evoked potentials index and the bispectral index during sedation induced by propofol or midazolam under epidural block. *Br J Anaesth* 2002; 89: 260–4.
 - 7 *Streiner DL, Norman GR.* Scaling responses. *In*: Streiner DL, Norman GR (Eds). *Health Measurement Scales: a Practical Guide to Their Development and Use*, 2nd ed. New York, USA: Oxford University Press; 1995: 28, 53.
 - 8 *Chernik DA, Gillings D, Laine H, et al.* Validity and reliability of the Observer's Assessment of Alertness/Sedation Scale: study with intravenous midazolam. *J Clin Psychopharmacol* 1990; 10: 244–51.
 - 9 *Newman MG, Trieger N, Miller JC.* Measuring recovery from anesthesia--a simple test. *Anesth Analg* 1969; 48: 136–40.
 - 10 *Chung F, Chan VW, Ong D.* A post-anesthetic discharge scoring system for home readiness after ambulatory surgery. *J Clin Anesth* 1995; 7: 500–6.
 - 11 *Bright E, Roseveare C, Dalglish D, Kimble J, Elliott J, Shepherd H.* Patient-controlled sedation for colonoscopy: a randomized trial comparing patient-controlled administration of propofol and alfentanil with physician-administered midazolam and pethidine. *Endoscopy* 2003; 35: 683–7.
 - 12 *Kortis HI, Amory DW, Wagner BK, et al.* Use of patient-controlled analgesia with alfentanil for extracorporeal shock wave lithotripsy. *J Clin Anesth* 1995; 7: 205–10.
 - 13 *Suttner S, Boldt J, Schmidt C, Piper S, Kumle B.* Cost analysis of target-controlled infusion-based anesthesia compared with standard anesthesia regimens. *Anesth Analg* 1999; 88: 77–82.