Effects of Surgical Position on Patients' Arterial Blood Gases During Percutaneous Nephrolithotomy

Hossein Karami, Alireza Rezaei, Mohammad Mohsen Mazloomfard, Babak Javanmard, Behzad Lotfi, Amir Haji-Mohammadmehdi-Arbab

Urology and Nephrology Research Center, Shohada-e-Tajrish Medical Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Corresponding Author:

Mohammad Mohsen Mazloomfard, MD
Urology and Nephrology Research Center, No.103, 9th Boustan St., Pasdaran Ave., Tehran, Iran

Tel: +98 21 2256 7222
Fax: +98 21 2277 0954
E-mail: mazloomfard@yahoo.com

Received August 2010
Accepted January 2012

Purpose: To compare arterial blood gas analysis of patients who underwent percutaneous nephrolithotomy (PCNL) in flank position under ultrasonography guidance with PCNL in prone and supine positions under fluoroscopic guidance.

Materials and Methods: In a clinical trial, a total of 90 patients with no upper urinary tract abnormalities were candidate for the PCNL. They were assigned into three groups using pseudorandomization method (30 patients in each group). Patients in group 1 underwent ultrasonography-guided PCNL in flank position. Patients in groups 2 and 3 underwent fluoroscopic-guided PCNL in prone and supine positions, respectively. Arterial blood gas was taken just before and 20 minutes after repositioning.

Results : The patients' mean age was 40.8 ± 6.9, 39.4 ± 10.6, and 37.2 ± 11.1 years in flank, prone, and supine positions, respectively ($P = .69$). The mean body mass index was 27.8 ± 3.4, 26.7 ± 4.7, and 28.1 ± 5.1 kg/m^2 in flank, prone, and supine positions, respectively ($P = .21$). Arterial oxygen pressure (PaO_2) increased significantly in flank (111.7 ± 43.8 to 132.8 ± 58.1 mmHg; $P = .01$) and prone (118.6 ± 50.2 to 134.6 ± 58.5 mmHg; $P < .001$) positions and decreased nonsignificantly in supine group (121.7 ± 64.5 to 119.7 ± 60.9 mmHg; $P = .23$). With surgical positioning, there were no significant changes demonstrated in $PaCO_2$ and serum concentration of HCO_3 in the flank, prone, and supine groups.

Conclusion: We could suggest that flank and prone positions could improve patients' oxygenation during PCNL procedure.

Keywords: percutaneous nephrolithotomy, blood gas analysis, prone position

INTRODUCTION

Change of position is a known cause of variation in pulmonary ventilation and perfusion. Atelectasis of the dependent areas of the lung due to general anesthesia has been shown to cause a progressive drop in arterial oxygen tension.[1]

Each position has its own effect on the patients' oxygenation and ventilation. Patients undergoing surgery in prone position are hemodynamically stable, with improved oxygenation and no significant changes in the alveolar dead space to tidal volume ratio.[2] This position has been reported to improve oxygenation in patients with acute respiratory distress syndrome.[3] Alternating the positions could also improve arterial oxygen pressure in these patients.[4] It has been shown that prone position is associated with an improvement in both oxygenation and carbon dioxide elimination, but lateral position has a beneficial effect on oxygenation without any effect on carbon dioxide elimination.[5]

The aim of this study was to compare arterial blood gas (ABG) changes after repositioning patients to prone, supine, and flank positions during percutaneous nephrolithotomy (PCNL).

MATERIALS AND METHODS

From January 2007 to October 2008, a total number of 90 patients were candidate for PCNL and assigned into three groups using pseudorandomization method (30 patients in each group). Patients in group 1 underwent ultrasonography-guided PCNL in flank position, while patients in groups 2 and 3 underwent fluoroscopic-guided PCNL in prone and supine positions, respectively.

All PCNLs were performed by a single team. The inclusion criterion was either pelvic or caliceal stones with a size greater than 2.5 cm in diameter. Patients with kidney anomalies, uncontrolled coagulopathies, previous history of PCNL or open renal stone surgery, known cardiovascular or respiratory disease, and children younger than 15 years were excluded from the study.

All the patients underwent general anesthesia in the lithotomy position, and after ureteral catheter insertion, they were repositioned to the flank, prone, or supine position according to their groups. All the patients received balanced anesthesia comprising of induction with fentanyl 2 to 6 µg/kg and propofol 1 to 2 mg/kg, muscle relaxation with atracurium 0.5 mg/kg, endotracheal intubation, invasive positive-pressure ventilation with nitrous oxide, oxygen, and isoflurane with alveolar concentration of 0.5 to 1.0 minimum.

Throughout the study, the ventilator settings (tidal volume, respiratory rate, I: E ratio, and FiO_2) were maintained at a constant level. The patients' heart rate, blood pressure, end-tidal carbon dioxide pressure, and oxygen saturation were monitored by using S/5™ Anesthesia Monitor (Datex Ohmeda, USA). Arterial blood gas levels were tested just before and 20 minutes after repositioning using ABL 330® blood gas analyzer (M/S Radiometer, Copenhagen, Denmark).

The study was approved by the Ethics Committee of Urology and Nephrology Research Center (UNRC) affiliated to Shahid Beheshti University of Medical Sciences. Written informed consents were obtained form all the participants.

Demographic characteristics, operation duration, hemoglobin levels, and ABG analyses were all compared in those three groups. Data were analyzed by SPSS software (the Statistical Package for the Social Sciences, Version 15.0, SPSS Inc, Chicago, Illinois, USA), using One-way ANOVA and one-way repeated measures ANOVA tests. *P* values less than .05 were considered statistically significant.

RESULTS

The mean patients' age was 40.8 ± 6.9, 39.4 ± 10.6, and 37.2 ± 11.1 years in flank, prone, and supine positions, respectively ($P = .69$). The mean body mass index was 27.8 ± 3.4, 26.7 ± 4.7, and 28.1 ± 5.1 kg/m^2 in flank, prone, and supine positions, respectively ($P = .21$). Demographic and clinical characteristics of patients are shown in Table 1.

Procedure's success rate was 86.7% in flank position, 90% in prone position, and 83.3% in supine position ($P = .56$). The mean duration of operation was 44.7 ± 6.4, 34.9 ± 5.1, and 33.1 ± 6.2 minutes in flank, prone, and supine positions, respectively ($P < .05$). The mean hospital stay was 2.7 ± 0.3, 2.9 ± 0.3, and 2.9 ± 0.3 days, respectively ($P = .89$).

None of the patients needed blood transfusion. There were no significant differences regarding the hemoglobin drop and complications, such as sepsis in the three groups.

Table 2 summarizes the ABG analyses data of patients in the three groups. After positioning, PaO_2 increased significantly in flank (111.7 ± 43.8 to 132.8 ± 58.1 mmHg; P = .01) and prone (118.6 ± 50.2 to 134.6 ± 58.5 mmHg; P < .001) positions and decreased nonsignificantly in supine group (121.7 ± 64.5 to 119.7 ± 60.9 mmHg; P = .23). The changes of PaO_2 seen in flank and prone groups were significantly different from that in supine group (P =.035). With surgical positioning, there was no significant changes in $PaCO_2$ in the flank group (35.5 ± 4.2 to 34.9 ± 5.1 mmHg; P = .2), prone group (34 ± 7.5 to 35.9 ± 6.7 mmHg; P = .2), and supine group (36.4 ± 8.1 to 37.6 ± 7.8 mmHg; P = .3). The changes of serum concentration of HCO_3 seen in flank, prone, and supine groups were not significantly different from each other.

DISCUSSION

Percutaneous nephrolithotomy can be carried out in different positions; the three common positions are prone, lateral, and supine. We demonstrated that oxygenation improves after the patient repositioning to prone and flank positions during PCNL procedure.

Alterations in distribution of pulmonary ventilation and perfusion with change of position have been shown in some studies.(6,7) The combined effect of position and general anesthesia on ABG may have a significant influence on the postsurgical events and rehabilitation in the patients who underwent surgery.

There were some publications which suggest that prone position yields better pulmonary function with improvement of oxygenation and carbon dioxide elimination. Mentzelopoulos and colleagues have shown that in patients with mechanically ventilated chronic obstructed pulmonary disease, repositioning to prone could facilitate oxygenation and lung mechanics during exhalation compared with semirecumbent position.(8) Furthermore, Pelosi and associates have found that in anesthetized and paralyzed obese subjects, the prone position improves pulmonary function and increases functional residual capacity, lung compliance, and oxygenation.(7) Radstrom and coworkers demonstrated that the kneeling prone position increases oxygenation, especially at the beginning of the mechanisms. Furthermore, the prone position does not change oxygen consumption; however, alveolar ventilation is significantly reduced. The author concluded that changes in alveolar ventilation could possibly be the result of circulatory changes caused by the prone position.(9) Papazian and colleagues have indicated that the prone position increases oxygenation and reduces lung inflammation in patients with acute respiratory distress syndrome.(10) In another study, Mure and associates found that the prone position increases the homogeneity of the ventilation perfusion distribution.(11)

Other studies also showed that the prone position together with positive end-expiratory pressure appears to improve ventilation-perfusion matching.(12,13) In the anesthetized mechanically ventilated patients, regional ventilation-perfusion distribution has been shown to be more uniform in the prone position. Prone position diminishes the percentage of the lung volume in the dependent zones and as a result, the volume of potentially collapsible lung.

During mechanical ventilation, the tidal volume is preferentially distributed to the nondependent areas of the lung that have a proportionately larger volume in the prone position compared to supine position; however, other investigations were not in favor of this suggestion. Lin and colleagues have revealed that positional change does not significantly contribute to gas exchanges, and there is no benefit of prone positioning in both pulmonary alveolar proteinosis patients and the healthy controls.(14) Soro and colleagues found that the alveolar dead space/tidal volume ratio does not change in the prone position and PaO_2/FiO_2 increases; however, it was not statistically significant. They also showed that patients undergoing surgery in prone position under general anesthesia for 3 hours are hemodynamically stable with no significant changes in the ratio of the alveolar dead space to the tidal volume.(2)

The effect of lateral position on arterial oxygenation under anesthesia is still under debate. Kerbl and colleagues performed PCNL in flank position to decrease pulmonary compression of the patients.(15) Gofrit and associates recommended the lateral position for the PCNL in patients with morbid obesity and in those who suffer from kyphosis to avoid severe hypoxemia and hypercarbia.(16) Although Manikandan and Rao revealed that prone position is associated with an improvement in both oxygenation and carbon dioxide elimination, yet lateral position has a beneficial effect on oxygenation without any effects on carbon dioxide elimination.[5] This was similar to our study, but we could not trace any changes in $PaCO_2$.

We demonstrated that PaO_2 increases after repositioning the patients to either flank or prone position, but supine position does not change patients' PaO_2. We also found that $PaCO_2$ and HCO_3 do not change during flank, prone, or supine positions in this percutaneous procedure.

However, this study was performed on patients with no history of cardiovascular or respiratory disease, abnormal deformity, such as kyphosis, or obesity. Therefore, these results could not be extended to the patients with such conditions. The results of the study indicate that prone and flank positions have similar positive effects on patients' oxygenation.

CONCLUSION

Flank and prone positions during surgery have positive effects on patients' oxygenation. We did not obtain ABG serially and at the end of PCNL; hence, in order to examine more chronic effects of patients' position on oxygenation and ventilation, serial arterial blood gases analyses during longer operations could be helpful.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Bendixen HH, Hedley-Whyte J, Laver MB. Impaired Oxygenation in Surgical Patients during General Anesthesia with Controlled Ventilation. A Concept of Atelectasis. N Engl J Med. 1963;269:991-6.
2. Soro M, Garcia-Perez ML, Belda FJ, et al. Effects of prone position on alveolar dead space and gas exchange during general anaesthesia in surgery of long duration. Eur J Anaesthesiol. 2007;24:431-7.
3. Fridrich P, Krafft P, Hochleuthner H, Mauritz W. The effects of long-term prone positioning in patients with trauma-induced adult respiratory distress syndrome. Anesth Analg. 1996;83:1206-11.
4. Kim MJ, Hwang HJ, Song HH. A randomized trial on the effects of body positions on lung function with acute respiratory failure patients. Int J Nurs Stud. 2002;39:549-55.
5. Manikandan S, Rao G. Effect Of Surgical Position On Pulmonary Gas Exchange In Neurosurgical Patients. Indian J Anaesth. 2002;46:356-9.
6. Lumb AB, Nunn JF. Respiratory function and ribcage contribution to ventilation in body positions commonly used during anesthesia. Anesth Analg. 1991;73:422-6.
7. Pelosi P, Croci M, Calappi E, et al. Prone positioning improves pulmonary function in obese patients during general anesthesia. Anesth Analg. 1996;83:578-83.
8. Mentzelopoulos SD, Zakynthinos SG, Roussos C, Tzoufi MJ, Michalopoulos AS. Prone position improves lung mechanical behavior and enhances gas exchange efficiency in mechanically ventilated chronic obstructive pulmonary disease patients. Anesth Analg. 2003;96:1756-67, table of contents.
9. Radstrom M, Loswick AC, Bengtsson JP. Respiratory effects of the kneeling prone position for low back surgery. Eur J Anaesthesiol. 2004;21:279-83.
10. Papazian L, Gainnier M, Marin V, et al. Comparison of prone positioning and high-frequency oscillatory ventilation in patients with acute respiratory distress syndrome. Crit Care Med. 2005;33:2162-71.
11. Mure M, Domino KB, Lindahl SG, Hlastala MP, Altemeier WA, Glenny RW. Regional ventilation-perfusion distribution is more uniform in the prone position. J Appl Physiol. 2000;88:1076-83.
12. Flaatten H, Aardal S, Hevroy O. Improved oxygenation using the prone position in patients with ARDS. Acta Anaesthesiol Scand. 1998;42:329-34.
13. Klingstedt C, Hedenstierna G, Lundquist H, Strandberg A, Tokics L, Brismar B. The influence of body position and differential ventilation on lung dimensions and atelectasis formation in anaesthetized man. Acta Anaesthesiol Scand. 1990;34:315-22.
14. Lin FC, Chen YC, Chang HI, Chang SC. Effect of body position on gas exchange in patients with idiopathic pulmonary alveolar proteinosis: no benefit of prone positioning. Chest. 2005;127:1058-64.
15. Kerbl K, Clayman RV, Chandhoke PS, Urban DA, De Leo BC, Carbone JM. Percutaneous stone removal with the patient in a flank position. J Urol. 1994;151:686-8.
16. Gofrit ON, Shapiro A, Donchin Y, et al. Lateral decubitus position for percutaneous nephrolithotripsy in the morbidly obese or kyphotic patient. J Endourol. 2002;16:383-6.