SCIENTIFIC ARTICLE

Robotic prostatectomy: the anesthetist’s view for robotic urological surgeries, a prospective study∗, †, ‡

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KEYWORDS
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Abstract
Background and objectives: Although many features of robotic prostatectomy are similar to those of conventional laparoscopic urological procedures (such as laparoscopic prostatectomy), the procedure is associated with some drawbacks, which include limited intravenous access, relatively long operating time, deep Trendelenburg position, and high intra-abdominal pressure. The primary aim was to describe respiratory and hemodynamic challenges and the complications related to high intra-abdominal pressure and the deep Trendelenburg position in robotic prostatectomy patients. The secondary aim was to reveal safe discharge criteria from the operating room.

Methods: Fifty-three patients who underwent robotic prostatectomy between December 2009 and January 2011 were prospectively enrolled. Main outcome measures were non-invasive monitoring, invasive monitoring and blood gas analysis performed at supine (T0), Trendelenburg (T1), Trendelenburg + pneumoperitoneum (T2), Trendelenburg-before desufflation (T3), Trendelenburg (after desufflation) (T4), and supine (T5) positions.

Results: Fifty-three robotic prostatectomy patients were included in the study. The main clinical challenge in our study group was the choice of ventilation strategy to manage respiratory acidosis, which is detected through end-tidal carbon dioxide pressure and blood gas analysis. Furthermore, the mean arterial pressure remained unchanged, the heart rate decreased significantly and required intervention. The central venous pressure values were also above the normal limits.

Conclusion: Respiratory acidosis and “upper airway obstruction-like” clinical symptoms were the main challenges associated with robotic prostatectomy procedures during this study.

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Introduction

Laparoscopic prostatectomy was first performed by Bhandari et al. in 1997 using a transperitoneal approach. An extraperitoneal approach was subsequently described by Raboy et al., with the first clinical cases of extraperitoneal laparoscopic radical prostatectomy using a robotic system described and reported by Pruthi et al. in 2003. The introduction of the da Vinci Surgical System has transformed the field of robotic surgery across the country and solved some of the limitations of traditional laparoscopic urology.

Robotic prostatectomy (RP) has enabled urologists to use a more controlled and accurate laparoscopic approach to radical prostatectomy. Compared to the open method, the robotic-assisted approach offers many advantages including better visualization and a more precise manipulation of delicate vessels and nerves. The surgeon can better preserve the integrity of the neurovascular bundles which results in improved postoperative urinary and sexual function. Other benefits include less postoperative pain, diminished scarring, reduced bleeding and shorter hospital stays.

Although many features of RP are similar to those of conventional laparoscopic urological procedures (such as laparoscopic prostatectomy), the procedure is associated with some drawbacks, which include limited intravenous access, relatively long operating time, deep Trendelenburg position, and high intra-abdominal pressure (IAP). Insufflation of the abdomen with CO₂ is not benign. Lung volume decreases, mean arterial pressure increases whereas cardiac index decreases, and absorption of CO₂ causes hypercarbia and a concomitant decrease in blood pH. Any of these alterations can lead to sudden cardiopulmonary distress. In addition, unintentional injury to vessels can lead to massive hemorrhage or CO₂ embolism requiring rapid resuscitation. Routine capnometry should be used in all laparoscopic cases as it allows the adequacy of mechanical ventilation to be assessed.

Currently, most of the knowledge about robotic urological surgery has been derived from the gynaecologic procedures performed in a less-deep Trendelenburg position and under lower IAP conditions; and studies of laparoscopic cholecystectomy surgeries that were performed under lower IAP, with a relatively short surgical duration, and in the head-up position, which can have different effects on patients’ respiratory and hemodynamic parameters as well as their risk of embolism. Herein, we aimed to describe the anesthetic challenges in RP procedures performed under deep Trendelenburg position and high IAP conditions. Additionally, we aimed to describe the criteria for safe discharge from the operating room.

Methods

Study design

Ethical approval from the local institutional committee and written informed consent from each consecutive patient were obtained. Fifty-three consecutive patients admitted to our clinic and who underwent RP between December 2009 and January 2011 were prospectively enrolled in the study. Non-invasive monitoring (ECG, pulse oximetry, and non-invasive blood pressure, body temperature, and respiratory...
parameters), invasive monitoring (mean arterial pressure and central venous pressure, and ventilator parameters) (Infinity Delta patient monitor, Draeger Medical Systems, Inc., Telford, PA 18969, USA) and blood gas analysis were performed at supine (T₀), Trendelenburg (T₁), Trendelenburg - pneumoperitoneum (T₂), Trendelenburg-before desufflation (T₃), Trendelenburg (after desufflation) (T₄), and supine (T₅) positions.

After anesthesia induction with pentobarbital 4–7 mg/kg and rocuronium 0.6 mg/kg, endotracheal intubation was performed. Anesthesia was maintained with remifentanil (50 mcg/mL) 1 mcg/kg/min in a 0.1 mcg/kg/min infusion and with 2 MAC sevoflurane, with additional boluses of rocuronium as needed. Each patient’s lungs were ventilated in volume-controlled ventilation mode using 50% oxygen in air with a set tidal volume (VT) and/or with breathing frequency (f) to achieve an end-tidal carbon dioxide pressure (PET-CO₂) of 25–30%, which was monitored with blood gas reports in parallel. Fluid management was considered in two intervals, before and after ureteral anastomosis. Fluid was relatively restricted before ureteral anastomosis. The second interval included a higher infusion rate to reach 2–3 mL/kg/h of the total fluid amount throughout the operation.

An arterial catheter was inserted in the left radial artery and central venous catheterization was performed through the right internal jugular vein to measure the central venous pressure (CVP). CVP was zeroed and measured on the mid-axillary line at the 4th intercostal space in the supine position. The peripheral intravenous access and arterial access were lengthened via lines. Ondansetron 4 mg was administered intravenously, and orogastric tubing was inserted with the patient in the supine position. The intraperitoneal pressure was adjusted to 18 mm Hg. Cerebral protection was assured by administering dexamethasone sodium phosphate 8 mg at the beginning of the operation and furosemide 40 mg.

During extubation, the patients were taken into a reverse Trendelenburg position, and diuretic administration was repeated to decrease upper airway edema might be caused by the prolonged use of the deep Trendelenburg position. Extubation was approved after a blood gas analysis confirmed normocapnia during minimally assisted spontaneous breathing and during spontaneous breathing of 10 L/min of ventilation on average, in the absence of or with reduced conjunctival, upper airway and tongue edema, with reversal of the neuromuscular blockade, and at a body temperature of 35 °C or more.

Safe extubation was performed in the operating room according to our discharge criteria and was properly managed as noted in Table 1. Complications from deep Trendelenburg positioning and anesthesia were recorded during and after surgery. The patients were classified according to their arterial pH levels at T₅ as pH<7.35 (the ones with acidosis at the end of surgery) and pH>7.35 (the ones with improved acidosis) classes. In these groups, types of acidosis developed intraoperatively and the management of acidosis were documented.

### Statistical analysis

Data were analyzed using the IBM Statistical Package for Social Sciences 19.0 (SPSS Inc., Chicago, IL). Paired-sample t-tests were used to assess the differences between groups. Chi-square test was carried out to compare the nominal variables.

### Results

Fifty-three robotic prostatectomy patients (53 males) were included in the study. The mean age was 60.12 ± 7.33, body mass index (BMI) was 27.30 ± 3.97, basal metabolic index was 27.30 ± 3.97, and American Society of Anesthesiologists (ASA) score was 1.72 ± 0.59 for the study group. As for the surgical variables, surgical time was 217.04 ± 80.73 min, Trendelenburg time was 262.45 ± 75.93 min, blood loss was 262.60 ± 90.00 mL, total fluids administered was 1680.00 ± 404.71 mL. NaHCO₃ was administered in 20% of the patients, and atripine was administered in 78.6% of the patients. The number of patients who presented pH < 7.35 was 35, while the number of patients who presented pH ≥ 7.35 was 18.

Table 2 shows the T₀ value and the T₁, T₂, T₃, T₄, and T₅ values for the hemodynamic and respiratory data, and ventilatory settings. The heart rates were significantly different between T₀ and T₁ (p = 0.0001), with a lower HR at T₁ than at T₀. The mean arterial pressure (MAP) value was significantly higher at T₁ than T₀ (p = 0.004). The mean CVP value was significantly higher at T₁, T₂, T₃, T₄, and T₅ than at T₀ (p = 0.0001 for all time points). The mean PET-CO₂ value at T₁ was significantly higher than T₀ (p = 0.005). The mean respiratory rate at T₅ was significantly higher than at T₀ (p = 0.031). The mean f values at T₂, T₃, T₄, and T₅ were significantly higher than T₀ (p = 0.017, p = 0.0001, p = 0.0001, respectively). The mean minute ventilation (MMV) at T₁, the anesthetist’s view for robotic urological surgeries

<table>
<thead>
<tr>
<th>Table 1</th>
<th>An integrated checklist for the safe extubation and discharge of robotic prostatectomy patients from the operating room/recovery room.</th>
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</thead>
<tbody>
<tr>
<td>Before extubation</td>
<td>Adequate breathing</td>
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</table>

**After extubation in the operating room**

- No snoring during either inspiration or expiration (or when the patient is awake, no sign of being affected by the neuromuscular block)
- No loud inspiration (when the patient is awake) and no sign that the patient is affected by the neuromuscular block
- No inspiratory difficulty or distress, (intercostal retraction, supraclavicular retraction, or retraction of the alae nasi during inspiration)

**MMV**, mean minute ventilation.
Table 2: Hemodynamic and respiratory data and ventilatory settings in the robotic prostatectomy.

<table>
<thead>
<tr>
<th>Variables</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean heart rate (beats/min) (T0)</td>
<td>67.29 (71.54)</td>
<td>62.45 (70.91)</td>
<td>69.98 (70.66)</td>
<td>67.13 (71.52)</td>
<td>75.91 (73.29)</td>
</tr>
<tr>
<td>(mm Hg) (T0)</td>
<td>91.00 (88.09)</td>
<td>101.56 (89.88)</td>
<td>95.33 (90.18)</td>
<td>91.04 (87.96)</td>
<td>94.41 (91.83)</td>
</tr>
<tr>
<td>Central venous pressure (mm Hg) (T0)</td>
<td>17.30 (6.70)</td>
<td>20.61 (7.84)</td>
<td>19.68 (8.39)</td>
<td>17.21 (6.55)</td>
<td>8.15 (7.84)</td>
</tr>
<tr>
<td>PET-CO2 (mm Hg) (T0)</td>
<td>32.40 (33.28)</td>
<td>33.76 (33.00)</td>
<td>35.40 (32.89)</td>
<td>34.27 (32.97)</td>
<td>34.84 (32.88)</td>
</tr>
<tr>
<td>SpO2 (%) (T0)</td>
<td>98.86 (99.14)</td>
<td>98.64 (99.04)</td>
<td>99.20 (99.00)</td>
<td>99.37 (99.20)</td>
<td>99.13 (98.98)</td>
</tr>
<tr>
<td>Respiration (T0)</td>
<td>15.68 (14.76)</td>
<td>16.93 (17.45)</td>
<td>15.85 (17.45)</td>
<td>17.04 (15.88)</td>
<td>20.35 (17.33)</td>
</tr>
<tr>
<td>Set f (breaths/min) (T0)</td>
<td>12.30 (12.03)</td>
<td>12.65 (12.10)</td>
<td>14.24 (12.07)</td>
<td>15.91 (12.03)</td>
<td>17.21 (12.11)</td>
</tr>
<tr>
<td>Set VT (mL) (T0)</td>
<td>577.41 (580.86)</td>
<td>581.33 (581.94)</td>
<td>579.98 (580.76)</td>
<td>579.22 (577.66)</td>
<td>575.80 (582.39)</td>
</tr>
<tr>
<td>Minute ventilation (mL/min) (T0)</td>
<td>6.34 (6.67)</td>
<td>6.60 (6.68)</td>
<td>7.41 (6.64)</td>
<td>8.54 (6.68)</td>
<td>8.97 (6.66)</td>
</tr>
<tr>
<td>Auto-PEEP (mm Hg) (T0)</td>
<td>1.66 (1.59)</td>
<td>1.60 (1.57)</td>
<td>1.51 (1.60)</td>
<td>1.39 (1.68)</td>
<td>1.74 (1.55)</td>
</tr>
<tr>
<td>Plateau pressure (mm Hg) (T0)</td>
<td>21.39 (12.36)</td>
<td>32.21 (12.77)</td>
<td>31.14 (12.98)</td>
<td>24.68 (12.16)</td>
<td>16.65 (13.14)</td>
</tr>
<tr>
<td>Peak pressure (mm Hg) (T0)</td>
<td>24.21 (14.79)</td>
<td>35.38 (15.81)</td>
<td>34.3 (15.81)</td>
<td>27.77 (14.87)</td>
<td>21.47 (16.17)</td>
</tr>
</tbody>
</table>

PET-CO2, end tidal carbon dioxide pressure; SpO2, saturation of peripheral oxygen; set f, set breathing frequency; set VT, set tidal volume.

* p < 0.05.

T3, T4, and T5 were significantly higher than T0 (p = 0.040, p = 0.0001, p = 0.0001, respectively). The mean plateau pressures and peak pressures at T1, T2, T3, T4, and T5 were significantly higher than the mean value at T0 (p = 0.0001 for all time points). No significant difference in the SpO2 values and in the PEEP values at any time point compared with T0 was observed (p > 0.05).

Patients with a pH < 7.35 exhibited significantly higher PaCO2 levels, compared with those with pH > 7.35 at T5 (p = 0.034). Base excess levels in patients with a pH < 7.35 were significantly lower when compared with those with pH > 7.35 at T5 (p = 0.024). Lactate and HCO3 levels at T5 did not show significant differences between patients with a pH < 7.35 at T5 and patients with a pH > 7.35 at T5 (p = 0.367, and p = 0.073, respectively) (Table 3). There were no significant differences in the set tidal volume (set VT) or the set breathing frequency (set f) at any time point during the operation between the patients with a pH < 7.35 and those with a pH > 7.35 (Table 4).

Anesthesia- and position-related complications observed included conjunctival edema (60.4%), regurgitation (15.1%), swollen tongue (15.1%), arrhythmia (bradycardia) (15.1%), head and neck edema (13.2%), loud inspiration (13.2), hyperemia of the head and neck (5.7%), difficulty on inspiration (3.8%), and neuropaxia (1.9%). The need for ICU was observed in 9.3% of the study group postoperatively.

**Discussion**

In the present study, we aimed to describe the anesthetic challenges related to the high IAP and deep Trendelenburg positioning in RP patients. Although deep Trendelenburg positioning and a prolonged IAP of 18 mmHg

Table 3: Arterial blood gas reports based acidosis determinants in both pH< 7.35 and pH> 7.35 cases of the robotic prostatectomy at T5.

<table>
<thead>
<tr>
<th>Determinants</th>
<th>pH&lt; 7.35 at T5 (n = 35)</th>
<th>pH&gt;= 7.35 at T5 (n = 18)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PaCO2 (mm Hg)</td>
<td>4485 ± 7.55</td>
<td>33.93 ± 3.15</td>
<td>0.034</td>
</tr>
<tr>
<td>Base excess (mEq/L)</td>
<td>-5.46 ± 1.57</td>
<td>-3.66 ± 1.53</td>
<td>0.024</td>
</tr>
<tr>
<td>Lactate (mg/dL)</td>
<td>13 ± 8.41</td>
<td>12.63 ± 4.17</td>
<td>0.367</td>
</tr>
<tr>
<td>HCO3 (mEq/L)</td>
<td>19.52 ± 2.78</td>
<td>22.02 ± 3.06</td>
<td>0.073</td>
</tr>
</tbody>
</table>
can produce adverse cardiovascular, respiratory, and neurological effects, Kalmar et al. have reported that the hemodynamic and pulmonary parameters remained within physiological limits in their RP study, which indicates that the Trendelenburg positioning and CO₂ pneumoperitoneum were well tolerated.⁷ The results of our study demonstrate that our hemodynamic and respiratory data differ from those reported by Kalmar et al. The difference might have resulted from our relatively larger clinical study of 53 patients who underwent RP procedures in a similar deep Trendelenburg position and a high mean IAP of 18 mmHg.

Changes in respiratory parameters require intense adjustments. Accordingly, the observed increases in the PET-CO₂ caused by decreases in the VT, which may have been due to the deep Trendelenburg positioning and pneumoperitoneum, were compensated by increases in the f and minute ventilation in order to prevent respiratory acidosis. The plateau pressures and peak pressures, which exceeded the normal limits due to both deep Trendelenburg positioning and pneumoperitoneum, were lowered by increasing the f conservatively, to avoid generating auto-PEEP. Changes in the intrathoracic pressure and the mechanical ventilation settings also could have led to PEEP generation. The high plateau and peak pressures observed in our study group at the end of the operations in the supine position may have been related to the patients’ spontaneous breathing efforts and/or possible residual pneumoperitoneum. The main clinical challenge in our study group was the choice of ventilation strategy to manage respiratory acidosis, which is detected through PET-CO₂ and blood gas analysis. First of all, increasing the breathing frequency to increase the MMV, which reduced the PET-CO₂ values, was required during Trendelenburg positioning with pneumoperitoneum. This result demonstrates that the increase in the PET-CO₂ was not due to a higher ASA score or pulmonary complications but rather to an increase in the PaCO₂ value caused by CO₂ pneumoperitoneum. Secondly, the plateau pressure (sum of the total PEEP and the driving pressure) was monitored to avoid going beyond a 35 mmHg limit. In the deep Trendelenburg position, the patients tended to develop auto-PEEP and intrathoracic pressures with high airway pressures, which may have compromised the VT through auto- or excessive PEEP and/or a reduced driving pressure. It is unknown whether a high IAP in a deep Trendelenburg position placed limitations on the driving pressure with or without high airway pressures, which might have compromised the VT. The effects of deep Trendelenburg positioning and a high IAP on lung mechanics are also unknown. The VT was adjusted to provide adequate ventilation without exceeding a peak airway pressure of 40 cm H₂O. As VT was reduced in the deep Trendelenburg position, an adjustment to MMV was made using f. To avoid or minimize auto-PEEP, the breathing frequency was adjusted to allow complete exhalation, with an inspiration-to-expiration ratio (I/E) of 1/2.

Peritoneal insufflation induces significant alterations in hemodynamics.¹⁰,¹¹ In our study, the increased PET-CO₂ may have been due to the use of a large amount of total CO₂ during insufflation prior to extubation and may have been due to inspiration and/or exhalation difficulties. Maintaining the PET-CO₂ between 32.40 and 35.40 mmHg resulted in PaCO₂ values of 33.23–41.60. These results suggest that the patients’ conditions had no negative effects on CO₂ removal. Additionally, as a non-invasive, indirect measurement, PET-CO₂ is an accurate means of monitoring PaCO₂, and deep Trendelenburg positioning does not diminish its usefulness.¹² The PET-CO₂ increases when the MMV is increased. In their RP study, Kalmar et al. reported higher PET-CO₂ and PaCO₂ values than ours, with PET-CO₂ values between 3.40 and 4.66 kPa, which resulted in a PaCO₂ between 4.66 and 6.00 kPa.⁷ These were no changes in the PET-CO₂, SpO₂, or respiration as the MMV was increased by increasing breathing frequency to provide the CO₂ removal and the neuromuscular block was reversed properly in this study. Although the plateau and peak pressures were reduced by the use of the supine position at the end of the operations, these pressures remained high during the procedures. However, both pressures reached their highest values during the deep Trendelenburg positioning with pneumoperitoneum.

Although an increase in arterial pressure and slightly increased HR are associated with peritoneal insufflation, a drop in cardiac output has been also reported in the literature, whether the patient is placed in the head-down or head-up position.¹²,¹³ In our study, although the MAP remained unchanged, the HR decreased significantly and required intervention. The CVP values were also above the normal limits. These high values might be due to the Trendelenburg positioning as they returned to their initial values by the end of the operation. Although the most obvious effects of the RP procedures on HR, MAP, and CVP in our study occurred immediately after the patients were moved into the Trendelenburg position with pneumoperitoneum, these measurements continued to be affected to a lesser degree until the supine positioning at the end of the procedures. The most obvious changes were observed in the CVP. The lactate did not increase; therefore, there was no indication that anaerobic metabolism occurred or contributed to the acidosis. In a study of 18 ASA-1 status patients, Torrielli et al. reported that increasing the IAP to 10 mmHg was associated with a decrease in the cardiac index that returned to its initial value after 10 min of 10° Trendelenburg positioning. They also reported that elevated IAP was associated with increases in the MAP and the systemic vascular resistance, and these values did not return to normal after peritoneal insufflation.¹⁴ In the present study, we observed the acute effects of Trendelenburg positioning with pneumoperitoneum as an increase in the MAP and a decrease in the HR, and both parameters had returned to their initial values at the subsequent time points. Kalmar et al. reported

| Table 4 Intraoperative changes in the set breathing frequency and set tidal volume at pH ≥ 7.35 and pH < 7.35 cases at T₅. |
|---------------------------------|-----------------|------------------|-----------|
|                                | pH < 7.35 at T₅ (n = 35) | pH ≥ 7.35 at T₅ (n = 18) | p Value  |
| Set tidal volume (mL)          | 553.81 ± 53.75    | 547.77 ± 78.82    | 0.446     |
| Set breathing frequency (breaths/min) | 16.27 ± 4.02     | 16.85 ± 4.12     | 0.342     |

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similar high-ASA related findings. Kordan et al. demonstrated that Trendelenburg positioning significantly increase MAP. In the present study, the MAP increased significantly at the beginning of the Trendelenburg positioning with no pneumoperitoneum. The increases in the CVP values in both deep Trendelenburg and 5° Trendelenburg positioning, with and without pneumoperitoneum, and the decreases in the CVP values to baseline at the end of the operation indicate a close relationship between CVP values and Trendelenburg positioning alone or with IAP.

Although the blood gas analyses were used to assess both respiratory and metabolic problems at all the time points, the presence of acidosis was determined as "pH < 7.35" and normal as "pH > 7.35" based on the blood gas reports at the end of the operation (T5). In this study, at all the time points, the diagnosed acidosis types were respiratory and metabolic acidosis. Increases in the set VT or the set f reflected respiratory acidosis management during the operation. The respiratory problems determined in the present study included the decrease in arterial pH due to the high PaCO2 pressure, and upper-airway and tongue edema due to the deep Trendelenburg position and endotracheal cuff pressure on the tongue base. The management strategy focused on avoiding any additional decrease in the pH, which could have worsened the blood gas parameters toward 7.20 pH and 18 mmol/L HCO3. Normocarbia and maintenance of an adequate MMV were the main goals in the blood gas monitoring during the surgical procedures and extubation assessment. Because the PaO2 and SPO2 did not decrease to critical values, no patients in either group required additional interventions.

Pruthi et al. reported 6.1 h of surgical time for cystoprostatectomy and a mean blood loss of 313 mL. The mean surgical time reported for their RP cases was similar to ours. In a study of the transfusion requirements in open and robotic-assisted laparoscopic radical prostatectomies, Kordan et al. demonstrated that RP was associated with lower blood loss and a smaller change in hematocrit than the open prostatectomy group. In our study, none of the patients required transfusions.

In a study by Bhandari et al., the perioperative complications during robotic RP included one anesthesia-related complication out of a total of 16 complications in 300 patients who underwent RP. It has been established that deep Trendelenburg positioning can cause decreases in functional residual capacity, total lung volume, and pulmonary compliance and may facilitate the development of atelectasis. In our study, the most frequent anesthesia- and position-related complications were conjunctival edema, regurgitation and "upper airway obstruction-like" clinical symptoms that might lead to or worsen respiratory acidosis. Phong et al. reported the clinical signs of upper airway edema via a reduction in the venous outflow from the head caused by pneumoperitoneum during prolonged, deep Trendelenburg positioning. We observed enlarged and dull, edematous tongues, snoring, loud inspiration, inspiratory difficulty, altered nasi retraction and supraclavicular retraction intercostal retractions when the patients awakened and were extubated. Endotracheal cuff pressure on the tongue base can cause and enhance tongue edema by preventing the lymphatic and venous drainage of the tongue. The use of the head-upright position prior to extubation, diuretic use when necessary and extubation itself improved these symptoms. Our criteria for discharge from the operating room, in addition to Aldrete scoring, included improvements in these upper airway signs and symptoms. The complications due to deep Trendelenburg positioning and/or pneumoperitoneum were limited to the operating room for most of the patients, the majority of whom did not demonstrate any need for admission to the ICU. In their study of perioperative complications during RP, Bhandari et al. demonstrated an overall complication rate of 5.3% and a major complication rate of less than 2% in their series, using the method of Clavien et al. In the present study, neurologic complications were rare and temporary, and they were recorded on the first day post-operatively in the ward. The only neurologic complication observed in the present study was a temporary unilateral sensory and motor neuropraxia in the right arm determined on the 1st postoperative day that lasted for 3 days, similar to a complication observed in the report by Yee et al. Arrhythmia can be induced by several causes in laparoscopic cases. In our study, bradycardia accounted for most of the arrhythmia cases during RP procedures, and these complications occurred immediately after the patients were moved into the Trendelenburg position and/or preceding the surgical procedure. We interpreted this timing as indicating that the arrhythmia resulted from the Trendelenburg position and/or the reflexes induced by the sudden stretching of the pneumoperitoneum, which may have caused an increase in vagal tone. Additionally, the remifentanil infusion may have a role in bradycardia in these cases. However, the bradycardia was not observed during the remifentanil infusions in any other parts of the surgical procedures.

The main purpose of the present study was to describe the anesthetic challenges related to the high IAP and deep Trendelenburg positioning in RP patients. However, the high IAP utilized in the present report could be responsible for several complications adding the deep Trendelenburg positioning. In animal studies, intraperitoneal pressures >20 mmHg resulted in intra-abdominal venous collapse, which occurred at lower levels of intraperitoneal pressure in the presence of hypovolemia. Thus, relative variation in intraperitoneal pressure and peripheral vessels may be the main determinants of vascular wall movements responsible for venous collapse and opening, and there could be situations that facilitate gas embolism. Increasing intraperitoneal pressure might reduce risk of gas embolism, but it could cause hemodynamic and respiratory instability in that position. Therefore, the challenge for clinicians is to obtain an optimal intraperitoneal pressure to balance between the risks of gas embolism and hemodynamic and respiratory instability during laparoscopic radical prostatectomy.

It must be clearly stated that the use of a lower IAP could certainly determine lower anesthetic complications such as respiratory acidosis, metabolic acid-base disorders, fluid management issues, position-related "upper airway obstruction-like" clinical symptoms, the maintenance of normocarbia, and the provision of adequate MMV. These respiratory problems may cause decreased arterial blood pH, and require special attention to prevent a worsening in acidosis, which exhibited much greater metabolic deterioration. In the management of these cases, medications and
ventilatory settings should be managed carefully. It is critical to monitor fluid infusion regimens (to manage metabolic asidosis), and the PET-CO$_2$ and blood gases to maintain normocarbia and an adequate MMW.

**Conflicts of interest**

The authors declare no conflicts of interest.

**References**