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Anesthesia management and patient outcomes in robotic assisted laparoscopic surgery: A single center experience

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Abstract

Robotic surgical techniques aimed to improve patient outcomes and satisfy patient outcomes while reducing surgical morbidity and mortality. One of the most performed surgeries, robotic assisted laparoscopic radical prostatectomy (RALRP), is characterized by many factors such as steep Trendelenburg position, and challenging access to the patient. We planned to evaluate anesthesia management and postoperative patient outcomes in RALRP. Patients planned for RALRP between January 2017 and June 2021 were included. Demographic data, additional diseases and Charlson Comorbidity Index (CCI) of the patients were recorded. The methods used in anesthesia maintenance, muscle relaxant and sugammadex dose, postoperative pain treatment protocol, duration of anesthesia and surgery, length of stay (LOS) in ICU or hospital, early postoperative complications and Clavien Dindo Classification (CDC) were evaluated by examining the follow-up forms in the intraoperative and postoperative period. Two hundred and sixteen patients underwent robotic assisted laparoscopic surgery between January 2017 and June 2021 and, 141 of them (65.3%) had RALRP. The mean age of the patients was 62.38±6.94, the body mass index was 27.60±3.94, and the mean CCI was 4.08±0.93. Total intravenous anesthesia (TIVA) (n=108, 76.6%) was mostly used for anesthesia maintenance. The median time spent during anesthesia was 278.5±63.6 minutes. The median time for surgery was 239.5±65.9 minutes. According to the CDC, grade-I was 5.7%, grade-II was 2.1%, grade-IVa 7.8%. The most common complication was acute kidney injury (11, 7.8%), followed by atelectasis (4, 2.8%). 98.6% of all patients were sent to the ward from PACU, except two. The mean LOS in hospital was 4.57±2.34 days. Robotic assisted laparoscopic radical prostatectomy is most performed surgery among all robotic surgeries. We think that, patient optimization and communication between surgeon and anesthesiologist is crucial to avoid the negative effects of steep Trendelenburg position and pneumoperitoneum in terms of improving outcome.

Keywords: Robotic surgery, prostatectomy, anesthesia, postoperative complication

Introduction

The advantages of minimally invasive surgery via laparoscopic or robotic techniques have led to its increasing use over the last few decades. Robotic surgical techniques have been used in urology, gynecology, cardiac, thoracic, upper and lower gastrointestinal and endocrine surgeries but, most commonly used for gynecologic and urologic surgeries. Compared with laparotomic techniques, robotic surgery allows smaller surgical incisions, reduces the perioperative stress response, reduces postoperative pain, reduces blood loss, results in decreased recovery times, and short LOS in hospital.

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One of the known endoscopic robotic systems was developed prior to 2000s: da Vinci robotic system (Intuitive Surgical Inc, Mountain View, CA, USA) in 2000 [1]. Robotic assisted laparoscopic radical prostatectomy (RALRP) has been the most commonly performed robotic surgery among others. As these robotic systems have been commercially available, only 766 RALRPs were done in the United States in 2002. However, 5 years later, this number had increased to 48 000, with a proportion of 68% of all radical prostatectomies [2,3]. The number of robotic assisted surgical procedures (RASP) has reached to approximately 644.000 according to the device manufacturers' data in 2017, in the USA [4]. This increase also leads to special considerations to anesthetic procedures and management for RASP. Anesthesia management for each patient and for each surgery will be unique. However, patient positioning, physiological effects of technique in robotic surgery, and potential patient safety issues are the challenges of anesthesiologist. Anesthetic management for robotic endoscopic surgery differ from those for patients undergoing open surgery, because of physiologic effects of pneumoperitoneum, absorption of CO_2, position for surgery, and prolonged operating times. The anesthetic risks related to robotic surgery are associated with length of operating time and position [5]. The most commonly seen complications were caused by the patient position and increased with obesity. Obese patients undergoing RALRP have increased complication rates compared with non-obese individuals [6].

Steep Trendelenburg is the only position for RALRP. The respiratory and cardiovascular effects of this position are the main anesthetic challenges. However, most of the patients can be managed with lung protective ventilation strategies including positive end-expiratory pressure and optimal restrictive fluid management. A steep Trendelenburg position trial before surgery give opportunity to decide whether an open procedure, or RALRP [7].

These likely complications establish the basis for the anesthetic technique. We will discuss the anesthetic management of patients having RALRP with advantages and disadvantages, and complications in our hospital with this study.

Material and Methods

After receiving ethical approval from Ankara University Faculty of Medicine Ethics Committee (Decision No: İ5-334-21), patients who underwent robotic surgery between January 2017 and June 2021 at Ankara University Faculty of Medicine Ibni Sina Hospital Robotic Surgery Operating Room were included in our study. This study was carried out in accordance with the "Principles of the Helsinki Declaration" and the guidance on Strengthening The Reporting of Observational Studies in Epidemiology (STROBE) [8].

All demographic data including age, sex, body mass index (BMI), The American Society of Anesthesiologists (ASA) physical status classification were recorded.

In our routine preoperative evaluation, a senior anesthesiologist performed a preoperative assessment the day before surgery. On the day of surgery, patients were taken to the operating room without premedication. All patients were followed according to the ASA monitoring guidelines, which consisted of noninvasive blood pressure, pulse oximetry (SpO_2), electrocardiogram, measurement of end-tidal carbon dioxide, bispectral index monitoring, and neuromuscular blockade monitoring (Carescape® B650 Monitor, GE, USA). After preoxygenation with 100%O_2 for 3minutes, anesthesia induction was performed with propofol 2-3mg/kg or thiopental sodium 4-6mg/kg and remifentanil 0.5-1µg/kg and rocuronium bromide 1mg/kg. All patients were intubated by a senior anesthesiologist using video laryngoscope. Sevoflurane was used for anesthesia maintenance with 50% air and O_2 and, titrated to a BIS value of 40-60. After intubation, left or right radial artery cannulation was done to monitor invasive arterial blood pressure and blood gas analyses.

Lung protective ventilation protocol was applied as tidal volume: 6 mL/kg (ideal body weight), PEEP: 6-10mmHg, Pplat <25cmH_2O, permissive hypercapnia (35<ETCO_2<45mmHg) and target SpO_2 >96%. PEEP was titrated after insufflation and steep Trendelenburg position, and recruitment maneuver was performed with 30 cmH_2O for 30 seconds when SpO_2 was <90. The respiratory rate was set to target an end-tidal carbon dioxide concentration of 35–45cmH_2O without exceeding the maximum peak airway pressure of 30 cmH_2O. A continuous infusion of rocuronium at 0.5-0.8mg/kg/hr was administered according to post-tetanic count and train-of-four (TOF). The rocuronium infusion was stopped after the robotic instruments were removed. Neuromuscular blockade was reversed using sugammadex (2-8mg/kg) based on TOF count of at least 90% of baseline value.

Because of the limited access to patient and duration of the procedure, the careful positioning of the patient is the most important issue to avoid position related complications during RALRP. When the patient was placed in position, all touchpoints including the head, shoulders, legs and arms were supported with standard silicone or foam pads. Patients were strapped to the operating table with chest straps to avoid sliding cephalad and even off the operating table but, without compromising the lung compliance in the steep Trendelenburg position with pneumoperitoneum. Some of the patients' legs were placed in padded boot stirrups for lithotomy, and we put the arms into the patient's side with foam rolls or silicone pads in the palms of their hands. After instrument removal and skin closure, intravenous-PCA was started with fentanyl or tramadol for postoperative pain control of the patients.

Demographic data of patients such as age, BMI, ASA physical status, and co-morbidities, perioperative and postoperative data were collected from patient files, records and electronic database. Anesthesia type, drugs used for induction, maintenance and recovery, especially doses of rocuronium and sugammadex, duration of anesthesia and surgery, fluids replaced during the surgery, intravenous drug used for PCA, postoperative early complications, length of stay in ICU and hospital, and mortality rates were recorded. Charlson Comorbidity Index (CCI) was used to evaluate preoperative comorbidities and Clavien Dindo Classification (CDC) was used to evaluate postoperative complications [9,10].

Statistical analyses were performed using SPSS version 11.5 (SPSS Inc., Chicago, IL, USA). Mean±standard deviation and median (minimum-maximum) were used for quantitative variables, and the number of patients (percentage) was used for qualitative variables.

Results

Of the 216 patients performed robotic surgery between January 2017 and June 2021, 141 of them (65.3%) were RALRP. Table I shows the distribution of robotic surgery cases during this period.

Table 1. Types of Robotic Surgery

	N (%)
Radical Prostatectomy	141 (64.1)
Partial Nephrectomy	26 (11.8)
Hysterectomy	10 (4.5)
Pyeloplasty	9 (4.1)
Sacrocolpopexy	9 (4.1)
Colorectal Surgery	5 (2.3)
Cystectomy	5 (2.2)
Mediastinal Mass	5 (2.2)
Seminal Vesiculectomy	2 (0.9)
Ureteroneocystostomy	2 (0.9)
Adrenalectomy	1 (0.5)
Thymectomy	1 (0.5)

The mean age of the patients included in the study was 62.38±6.94, and their BMI was 27.60±3.94. ASA classifications, CCI and co-morbidity of these patients are given in table 2 according to the retrospective file scanning. The majority of the patients were ASA class II (53.9%) patients.

As explained in detail in the material and method section, it was determined that TIVA was the most preferred and applied method in anesthesia induction and maintenance (76.6%). The total dose of rocuronium administered during induction and during TOF monitorization was 157.9 ± 53.02mg. A total of 251.55±157.98mg of sugammadex was administered to these patients.

In accordance with their current co-morbidity and general application protocol, 95% of the patients underwent invasive arterial blood pressure monitoring by performing arterial cannulation, and accordingly, vasodilator treatment was applied to 17% of the patients and vasoconstrictor treatment was applied to 14.2%. In total, 2411.24±674.43mL crystalloids were given to these patients in the perioperative period.

The pain management maintained mostly by iv patient controlled analgesia, 82 (58.2%) patients received tramadol hydrochloride and 59 (41.8%) patients received fentanyl for postoperative analgesia. The median time spent during anesthesia was 278.53±63.68 minutes. The median time for surgery was 239.53±65.95 minutes (Table II).

Table 2. Demographic data of RALRP patients and anesthesia and surgery data

	Mean±SD	Median (Min-Max)
Age	62.38±6.94	**63.0 (36.0-80.0)**
BMI	27.60±3.94	**27.08 (19.45-38.10)**
ASA, n (%)		
I	49 (34.8)	
II	76 (53.9)	
III	16 (11.3)	
CCI	4.08±0.93	4.00 (2.0-7.0)
Hypertension, n (%)	64 (45.4)	
Coroner Arter Disease, n (%)	26 (18.4)	
Diabetes Mellitus, n (%)	19(13.5)	
COPD, n (%)	6 (4.3)	
Others, n (%)		
Hypothyroidism	3 (2.1)	
Asthma	2 (1.4)	
Pulmonary Embolism	1 (0.7)	
Chronic renal failure	2 (1.4)	
Glaucoma	3 (2.1)	
Aortic Aneurysm	1 (0.7)	
Arrhythmia	3 (2.1)	
Cerebrovascular event	1 (0.7)	
Anesthesia management, n (%)		
TIVA	108 (76.6)	
Inhalation	33 (23.4)	
Intraoperative fluid (mL)	2411.24±674.43	2500.00 (700.00-4500.00)
PCA (iv), n (%)		
Tramadol	82 (58.2)	
Fentanyl	59 (41.8)	
Anesthesia Duration (minute)	278.53±63.68	280.00 (160.00-540.00)
Surgical Duration (minute)	239.53±65.95	240.00 (30.00-500.00)

BMI: Body mass index, ASA: American Society of Anesthesiologists, CCI: Charlson comorbidity index, COPD: Chronic obstructive pulmonary disease, TIVA: Total intravenous anesthesia, PCA: Patient-controlled analgesia

The acute kidney injury (AKI) (11, 7.8%) was the most common complication. In addition, atelectasis (4, 2.8%), emphysema (2, 1.4%), nausea and vomiting (2, 1.4%), urinary tract infection (2, 1.4%), and other complications were also less frequently seen (Table IV). It was determined that the patients who developed AKI were mostly stage 1 (63.6%), and less frequently stage 2 (27.3%) and stage 3 (9.1%). According to the CDC, grade-I was 5.7%, grade-II was 2.1%, grade-IVa 7.8% when complications were evaluated. 98.6% of the patients were sent to the ward from PACU. The mean LOS in hospital was 4.57±2.34 days (Table III).

Table 3. Complication rates

Complication, n (%)	Acute Kidney Injury	11 (7.8)
	Atelectasis	4 (2.8)
	Emphysema	2 (1.4)
	Nausea and vomiting	2 (1.4)
	Urine infection	2 (1.4)
	Fever	1 (0.7)
	Hypothermia	1 (0.7)
	Subconjunctival Hemorrhage	1 (0.7)
	Haematoma	1 (0.7)
	Shoulder pain	1 (0.7)
CDC, n (%)	none	119 (85.1)
	I	8 (5.7)
	II	3 (2.1)
	IVa	11 (7.8)
Postop ward/ICU, n (%)	ward	139 (98.6)
	ICU	2 (1.4)
ICU stay(day)	Mean±SD	1.00±0.00
Hospital stay (day)	Mean±SD	4.57±2.34

AKI:Acute kidney injury, CDC:Clavien Dindo classification, ICU: Intensive care unit

Discussion

From the early 2000s, RALRP has been the most commonly performed robotic procedure worldwide as it has the advantages of less postoperative pain, smaller incisions, less complication rates with short LOS in hospital, and faster return to work comparing to open abdominal surgery. This preference also leads to special considerations to anesthetic management for RALRP. In this surgical population, serious considerations are based around position due to physiological effects and potential patient safety issues [11]. Robotic surgery started at 2015 in our hospital and, RALRP is also the most common robotic surgery performed in hospital among all robotic surgeries with a percentage of 65.3% (n=216 vs 141).

Overall non-surgical complication rate was 9.9% for RALRP in our study. Our clinical anesthesia management protocol for RALRP was based on a standardized protocol, which begins from the preoperative evaluation and continues with careful positioning on the operative table. Even to a precise approach it was not able to prevent acute kidney injury (7.8%), atelectasis (2.8%) or, nausea and vomiting (1.4%). But these complications did not affect the LOS in PACU, or hospital. Although RALRP has fine surgical outcomes such as less blood loss, small surgical incision, and short LOS in hospital, these techniques bring new challenges to anesthesiologists.

Joo et al. reported that the LOS in hospital is significantly short in RALRP compared to open radical prostatectomy (RRP) (7.0±2.5

days vs 8.8±3.0 days) [12]. Gainsburg et al. reported that the LOS in ICU and hospital were reduced by 30% and 67% compared to open prostatectomy [13]. In our study, the mean LOS in hospital was 4.57±2.34 days, and we think, this is related to the low postoperative non-surgical complication rates. Duration of surgery is also an important issue for other expected complications and, this is a result of learning curve for surgeons and anesthesiologist. Duration of surgery depends on the surgeon's experience and range from 160 to 296 minutes as reported in Gainsburg's study [11]. Compared to open surgical techniques, RALRP is significantly longer. This is mainly because of patients' preparation process and, also because of the need and usage of special equipment. Our data is similar to literature, and duration of surgery shortens in time correlated to the learning curve.

The anesthetic risks of patients undergoing RALRP are mainly related to the effect of pneumoperitoneum with steep Trendelenburg position and the length of operating time. The most frequent non-surgical complications are peripheral neuropathies, mainly due to brachial plexus injuries, corneal oedema and abrasions, posterior ischemic optic neuropathy, and the effects of edema (most significantly cerebral, ocular and laryngeal), which are described by Maerz et al. in detail [5]. Therefore, the anesthetic management of RALRP patients starts with a thorough preoperative evaluation, and continues with careful positioning on the operative table, managing ventilation issues, and appropriate fluid management. Close coordination between the anesthesia and surgical teams is also required for a successful surgery and outcome.

Anesthetic management in each RALRP surgery is unique. However, similar problems are based on the physiological effects of patient positioning, and patient safety due to the restricted patient access. After positioning the patient with safety, the aim of anesthesiologist is to provide safety, surgical facility with optimal anesthesia and to improve recovery without postoperative nausea and vomiting, pain and discharge with patient fulfilment.

The steep Trendelenburg position is required for urologic robotic surgeries, but it affects the respiratory and cardiovascular dynamics. However, majority of patients planned for RALRP, should be managed with lung protective pressure control ventilatory strategies with positive end-expiratory pressure and optimal fluid management to prevent the negative effects of the position. In a study by Danic et al., decrease in mean arterial pressure and cardiac output has shown in Trendelenburg position [14]. In our study, only 14.2% of the patients needed vasoconstrictor agent, this can be explained by ASA status of our patients, only 11.3% of our patients were ASA III, so other patients could able to tolerate the hemodynamic changes.

Thoracopulmonary compliance and functional residual capacity decreases by the effect of steep Trendelenburg position during RALRP [15-17]. Kalmar et al. also showed that SpO_2 decreased to 90% during steep Trendelenburg position [15]. All these parameters result in increased postoperative pulmonary complications with an incidence of 30.9% BMI, hypoalbuminemia, low or zero PEEP during surgery and, age are defined as risk factors for postoperative pulmonary complications (PPC). PEEP has also been found the main factor to reduce PPC in Yu's retrospective study [18]. PEEP is one of the main targets of our anesthesia protocol during RALRP, as a part of lung protective ventilation in steep Trendelenburg. We start with 4-6mmHg PEEP after intubation, and then increased PEEP to 6-10 mmHg after insufflation and steep Trendelenburg position. Our PPC rate was only 2.8% (4 patients), which was defined as desaturation (SpO_2<90%) due to atelectasis.

Total intravenous anesthesia is the most preferred anesthesia maintenance technique for robotic procedures. The advantages of TIVA in terms of reduction in PONV and short recovery makes it the choice of anesthesia in RALRP [19].

Oedema can become a serious problem after a prolonged surgery in the steep Trendelenburg position. Not only eyes and cranial oedema but, laryngeal oedema may also occurs. The overall incidence of reintubation after robotic surgery is around 0.7%, and delayed extubation 3.5%; but the incidence of airway oedema may be up to 26% [5]. None of our patients needed reintubation after surgery. Only one of them had subconjunctival hemorrhage.

Facial and visible periorbital oedema are the signs for laryngeal oedema and corneal abrasions [20]. In RALRP, a higher rate of corneal ablation is seen compared to open radical prostatectomy (0.35% vs 0.19% respectively) [21]. However, in a study evaluating 1.500 patients who underwent robotic prostatectomy, the most common complication related to anesthesia was corneal abrasions, occurring in 3% of cases [14]. During positioning taping, padding, and drapes should be used for all patients to protect touchpoints. Visual loss is rare with posterior ischemic optic neuropathy [22].

Position and duration of surgery may also cause cerebral oedema resulting in reduced consciousness postoperatively. Limiting operative time, minimizing the angle of steep Trendelenburg position, decreasing the insufflation pressure to minimal levels if possible, maintaining normal $ETCO_2$ concentration, and fluid restriction may prevent cerebral oedema.

Once the patient is locked prior to surgery, restricted access and the absolute need for immobility causes several challenges for the anesthetist. Awareness is crucial during positioning with pads, chest banding to stabilize during steep Trendelenburg. These strategies can prevent the position related complications. Incidence of peripheral nerve injury after robotic surgery is high (6.6%) but generally resolves in six weeks [23]. Our protocol compel us to take care of positioning with pads and, bindings. Our results show that our attention prevented nerve injuries in our patients. Only one patient had experienced shoulder pain and resolved within a few days.

Fluid restriction reduce the complications in association with oedema, but needs to be balanced against complications of the cardiovascular and renal systems. AKI is an important complication associated with prolonged hospital stay, and increases the morbidity and mortality. The incidence of AKI in RALRP is significantly lower than in RRP (respectively 5.5% vs 10.4%) [12]. There are conflicting results about RALRP and renal failure. While in a study conducted by Ahn. et al, they have demonstrated no change in GFR in RALRP, Cho et al. reported transient increase in serum creatinine [24,25]. However, it has been reported that the risk of AKI increases as the duration and pressure of pneumoperitoneum increases and results in a decrease in renal function which prolongs up to 1 year after surgery [26]. Our data showed that 7.8% of our patient showed AKI. Grade 2 AKI developed in 2.2% of the patients, and grade 3 AKI developed in 0.7% of the patients, and one patient required dialysis. While operative time and anesthesia time are significantly longer in RALRP than in the RRP, the incidence of transfusion and packed red blood cell transfusion could be less. Studies are still needed to determine risk factors for AKI in patients who underwent RALRP.

Conclusion

As the number of RALRP are increasing parallel to the improvement of medical technology, anesthesiologists should be aware of the perioperative concerns in these patients. Position related complications, impaired respiratory mechanics due to pneumoperitoneum and the steep Trendelenburg position, risk of inappropriate fluid management for excessive urine output to operative field and AKI, and cerebral oedema which poses a risk for cognitive impairment are the most important challenges to be overcome for the anesthesiologist. We believe that patient optimization starting from the preoperative evaluation and the coordination between the anesthesiologist and surgeon is crucial to guarantee the improved outcome.

Conflict of interests

The authors declare that there is no conflict of interest in the study.

Financial Disclosure

The authors declare that they have received no financial support for the study.

Ethical approval

After receiving ethical approval from Ankara University Faculty of Medicine Ethics Committee (Decision No: İ5-334-21), patients who underwent robotic surgery between January 2017 and June 2021 at Ankara University Faculty of Medicine Ibni Sina Hospital Robotic Surgery Operating Room were included in our study. This study was carried out in accordance with the "Principles of the Helsinki Declaration" and the guidance on Strengthening The Reporting of Observational Studies in Epidemiology (STROBE) [8].

References

1. Ashrafian H, Clancy O, Grover V, Darzi A. The evolution of robotic surgery: surgical and anaesthetic aspects Br J Anaesth. 2017;119:72-84.
2. Murphy DG, Hall R, Tong R, et al. Robotic technology in surgery: current status in 2008. ANZ J Surg. 2008;78:1076-81.
3. Abboudi H, Khan MS, Aboumarzouk O, et al. Current status of validation for robotic surgery simulators - a systematic review. BJU Int. 2013;111:94-205.
4. Grogan RH. Current status of robotic adrenalectomy in the United States. Gland Surg. 2020;9:840-3.
5. Maerz DA, Beck LN, Sim A, Gainsburg DM. Complications of robotic-assisted laparoscopic surgery distant from the surgical site. Br J Anaesth. 2017;118:492-503.
6. Ellimoottil C, Roghmann F, Blackwell R, et al. Open versus robotic radical prostatectomy in obese men. Curr Urol. 2015;8:156-61.
7. Kilic OF, Borgers A, Kohne W, et al. Effects of steep Trendelenburg position for robotic-assisted prostatectomies on intra- and extrathoracic airways in patients with or without chronic obstructive pulmonary disease. Br J Anaesth. 2015;114:70-6.
8. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Bull World Health Organ. 2007;85:867-72.
9. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40:373-83.
10. Clavien PA, Sanabria JR, Strasberg SM. Proposed classification of complications of surgery with examples of utility in cholecystectomy. Surgery. 1992;111:518-26.
11. Gainsburg DM. Anesthetic concerns for robotic-assisted laparoscopic radical prostatectomy. Minerva Anestesiol. 2012;78:596-604.
12. Joo EY, Moon YJ, Yoon SH, et al. Comparison of acute kidney injury after robot-assisted laparoscopic radical prostatectomy versus retropubic radical prostatectomy: a propensity score matching analysis. Medicine (Baltimore). 2016;95:2650.
13. Gainsburg DM, Wax D, Reich DL, et al. Intraoperative management of robotic-assisted versus open radical prostatectomy. JSLS. 2010;14:1-5.
14. Danic MJ, Chow M, Alexander G, et al. Anesthesia considerations for robotic-assisted laparoscopic prostatectomy: a review of 1,500 cases. J Robot Surg. 2007;1:119-23.
15. Kalmar AF, Foubert L, Hendrickx JF, et al. Influence of steep Trendelenburg position and CO($_2$) pneumoperitoneum on cardiovascular, cerebrovascular, and respiratory homeostasis during robotic prostatectomy. Br J Anaesth. 2010;104:433-9.
16. Hirvonen EA, Nuutinen LS, Kauko M. Hemodynamic changes due to Trendelenburg positioning and pneumoperitoneum during laparoscopic hysterectomy. Acta Anaesthesiol Scand. 1995;39:949-55.
17. Choi SJ, Gwak MS, Ko JS, et al. The effects of the exaggerated lithotomy position for radical perineal prostatectomy on respiratory mechanics. Anaesthesia. 2006;61:439-43.
18. Yu J, Park JY, Kim DH, et al. Incidence and Risk Factors of Pulmonary Complications after Robot-Assisted Laparoscopic Prostatectomy: A Retrospective Observational Analysis of 2208 Patients at a Large Single Center. J Clin Med. 2019;8:1509.
19. Herling SF, Dreijer B, Wrist Lam G, et al. Total intravenous anaesthesia versus inhalational anaesthesia for adults undergoing transabdominal robotic assisted laparoscopic surgery. Cochrane Database Syst Rev. 2017;4:CD011387.
20. Weber ED, Colyer MH, Lesser RL, Subramanian PS. Posterior ischemic optic neuropathy after minimally invasive prostatectomy. J Neuroophthalmol. 2007;27:285-7.
21. Sampat A, Parakati I, Kunnavakkam R, et al. Corneal abrasion in hysterectomy and prostatectomy: role of laparoscopic and robotic assistance. Anesthesiology. 2015;122:994-1001.
22. Gkegkes ID, Karydis A, Tyritzis SI, Iavazzo C. Ocular complications in robotic surgery. Int J Med Robot. 2015;11:269-74.
23. Mills JT, Burris MB, Warburton DJ, et al. Positioning injuries associated with robotic assisted urological surgery. J Urol. 2013;190:580-4.
24. Ahn JH, Lim CH, Chung HI,et al. Postoperative renal function in patients is unaltered after robotic-assisted radical prostatectomy. Korean J Anesthesiol. 2011;60:192-7.
25. Cho JE, Shim JK, Chang JH, et al. Effect of nicardipine on renal function after robot-assisted laparoscopic radical prostatectomy. Urology. 2009;73:1056-60.
26. Sato H, Narita S, Saito M, et al. Acute kidney injury and its impact on renal prognosis after robot-assisted laparoscopic radical prostatectomy. Int J Med Robot. 2020;16:1-7.