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Research Article

Early experience in anesthesia of robot assisted cystoprostatectomy

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Anesthesia monitoring;
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Abstract *Objective:* Robot assisted cystectomies have recently been undertaken in our institute. We will discuss the perioperative management of the first 25 cases of robot-assisted cystprostatectomies with urinary diversion.

Methodology: The study was conducted on 25 consecutive patients who underwent robotic radical cystprostatectomies with urinary diversion. Hemodynamic, pulmonary data and ABG changes were recorded.

Results: There were significant increase in mean arterial blood pressure, CVP and arterial carbon dioxide tension, plateau airway pressure after pneumoperitoneum and trendlenberg position with significant decrease in lung compliance.

Conclusion: Robotic assisted radical cystectomy in the exaggerated trendlenberg position is a challenging clinical setting to anesthetists. Continuous monitoring intraoperatively and postoperatively with rapid interaction with anticipated events and potential risks is essential.

1. Introduction

Minimally invasive surgery is being incorporated more frequently into urologic practice and appears to be replacing many open procedures. Robotically-assisted surgery is well established and will likely to play an increasingly important role in the future of surgical procedures. The technology of robotic assistance has the potential to improve the surgical outcome and overcome many limitations and reduce complications of conventional laparoscopy [1,2]. It allows better visualization, and more ergonomic instrument control and may be associated with several intra- and perioperative advantages in terms of blood loss, return to bowel function and hospital discharge but it has potential difficulties while on the steepest part of the learning curve.

The combination of the positioning and CO_2 insufflations for long periods could make ventilating these patients

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challenging, and is likely to cause significant physiological side effects due to the widespread changes in body system [3,4].

Robot assisted cystectomies have recently been undertaken in our institute.

The aim of this study was to discuss the perioperative management of the first 25 cases of robot-assisted cystoprostatectomies with urinary diversion and investigate the effect of steep Trendelenburg position and pneumoperitoneum on respiratory and hemodynamic homeostasis.

2. Methodology

After obtaining approval from our institutional Medical Ethics Committee, the study was conducted on 25 consecutive patients who underwent Robotically-assisted radical cystectomy and urinary diversion at National Cancer Institute, Cairo University during the period (from July 2011 till January 2012). All patients were prepared preoperatively by history, physical examinations, kidney and liver function tests, chest X-ray, abdominal–pelvic CT scan, cystoscopy with bimanual examination under anesthesia + biopsy or/ trans-urethral resection of the tumors together with bone scan if indicated for clinical staging and to rule out systemic metastases.

All procedures were performed using a four-arm da Vinci robotic system. All cases in our series were performed by the same group of surgeons. A bedside assistant and an operating theatre nurse who are experienced in RARC procedure were part of the team.

0.1 mg/kg^{-1} midazolam as premedication was administered. Prophylaxis against thromboembolism was carried out with low-molecular weight heparin and elastic stockings.

Upon arrival in the operating theatre, standard monitoring was applied: ECG, pulse oximetry and non-invasive automated arterial blood pressure. A lumbar epidural catheter was inserted and anesthesia was induced with sleeping dose of thiopentone, fentanyl (2 $\mu g\,kg^{-1}$) and rocuronium (0.6 $mg\,kg^{-1}$) the trachea was intubated. And anesthesia was maintained by intravenous boluses of morphine and 1–2 MAC isoflurane to help minimizing changes in HR and arterial BP. rocuronium (0.6 $mg\,kg^{-1}$) was administered when needed and the lungs were ventilated with oxygen enriched air and ventilation was manipulated to minimize excessive increases in end tidal carbon dioxide as possible. Epidural boluses or infusions were not used at this stage.

After induction of general endotracheal anesthesia a naso-gastric tube and nasopharyngeal probe to monitor temperature and urinary catheter are inserted. A two-lumen central venous catheter cannulation (CVP) was done through internal jugular approach (Arrow International Inc., Reading, PA) for monitoring of central venous pressure. The external acoustic meatus was used as the zero reference point, to allow a precise determination of the cerebral perfusion pressure, independent of patient positioning. Arterial cannula was fixed for invasive arterial blood pressure monitoring, a 20-gauge arterial catheter (Arterial Cannula, REF 682245, Becton Dickinson, Swindon, UK) was inserted percutaneously into a radial artery. The catheter was connected via a 150-cm long (1.5 mm internal diameter) rigid pressure tubing, filled with saline, to a continuous-flush pressure-transducer system (Becton Dickinson Critical Care Systems, Singapore) to monitor blood pressure and for arterial blood sampling.

Temperature control is maintained with a forced-air warming system, cotton wrappings of the extremities and blanket, and warm fluid infusion.

All vital signs were monitored using an S5-monitor and data from the monitor were recorded via Collect Software (Datex).

The patient was then strapped to the bed. The eyes were covered with paraffin gauze and padded. The patient was gradually positioned in steep trendelenburg position, keeping a watch on airway pressure. The robotic ports were inserted and pneumoperitoneum was created. The abdominal cavity was insufflated with CO_2 to a pressure of 15 mmHg; all operations were performed with the same degree of trendelenburg.

The increases in HR and arterial pressure induced by the creation of pneumoperitoneum (PP) and steep trendelenburg tilt (TT) were ameliorated by the stepping up anesthesia concentration and infusion of nitroglycerine if needed. Only replacement and maintenance fluids were given, and maintaining adequate dieresis, if the central venous pressure showed a higher value (more 30 cm H_2O), then fluids were further restricted. Blood transfusion was instituted when necessary guided with losses and hematocrite value.

After completing the extirpative portion of the procedure, the robot was undocked and, the pneumoperitoneum was released. Patient was made supine and ports were removed and extracorporeal urinary diversion (ileal conduit, rectosigmoid bladder or orthotopic neobladder) was performed via a 6–8-cm lower midline incision. We gave epidural bolus at this stage, 0.25% bupivacaine 10–12 ml with 3 mg of morphine after negative test dose of 3 ml of xylocaine with adrenaline. In three cases an intracorporeal diversion (one Studer ileal neobladder and two ileal conduits) was done.

During the procedure, invasive arterial pressure, central venous pressure, core body temperature, respiratory dynamics and the CPP (calculated as the difference between MAP and CVP)were recorded and arterial blood samples were periodically withdrawn for gasometry, (Radiometer 715, Radiometer Medical APS, Brønshøj, Denmark) at 10 min after induction, during steep trendelengburg,after inflation, 2 h and 4 h after starting robotic surgery, after deflation and 15 min after resuming the supine position, 2 h after open supine surgery, before extubation and 2 h after recovery.

The amounts of total blood loss as well as the need for blood transfusions, intraoperative use of vasopressors or antihypertensives, were all recorded, if towards the end of the surgery, the central venous pressure was high or there was conjunctival edema, we gave shots of 5 mg lasix.

The patients were discharged to PACU where evaluation by the anesthetist was done, duration of stay in the recovery room till reaching Aldrete score of 10/10 [5] was recorded. Number of patients needing ICU admission was recorded .The patients were given epidural boluses of morphine 3 mg in 10 ml of saline every 12–24 h for the next 3 days in the ward. All patients were made mobile the next day of surgery.

All statistical analyses were performed with a statistical software package (SPSS/PC+; SPSS Inc., Chicago, IL). The data were analyzed by analysis of variance for repeated measurements using one dependent variable and one within-subject factor (time).When significant effects of time were observed, these were evaluated by means of the paired Student's *t*-test with

Bonferroni's correction. P value of < 0.05 was considered statistically significant.

3. Results

The medical records of all patients who had undergone robotic radical prostatectomy at our institution were reviewed. Patient demographic data, clinical data are displayed in Table 1. Heart rate changes did not display any significance but the mean blood pressure and CVP increased significantly in comparison to the basal reading during nearly all insufflations period (Table 2). Following PP deflation, MBP and CVP gradually returned to within normal range period. In the first five minutes after trendelenburg positioning, the MAP increased more than the increase in CVP thus increased the calculated CPP significantly then, the MAP and CVP decreased modestly. After resuming the supine position, both the MAP and CVP decreased markedly and significantly compared to previous values but to the same extent, leading to a transient significant decrease in CPP to 60 [5] mmHg immediately after reassuming the supine position which subsequently recovered to baseline values.

$PaCO_2$ showed progressive significant increase throughout the procedure to reach maximum value before deflation with significant respiratory acidosis which gradually resolved Following PP deflation (Table 2). PaO_2/FiO_2 decreased significantly with trendelenburg position (Table 2). The arterial oxygen saturation was stable throughout the procedure. The respiratory plateau pressure (Plat) gradually increased significantly during trendelenburg positioning, and then further increased after applying CO_2 peritoneum thereafter, it remained stable throughout the trendelenburg and pneumoperitoneium period. After reinstitution of supine position, the respiratory plateau pressure Plat returned to nearly the same level as the baseline value. Reciprocally, the compliance decreased significantly gradually during trendelenburg positioning and remained stable throughout the trendelenburg period. After reinstitution of supine position, the compliance increased gradually but it was significantly lower than the baseline value (Table 2). The MV requirement increased significantly after creation of the pneumoperitoneum, and increased somewhat further during the procedure as well as for a few minutes after the release of the IAP (Table 2).

Table 1 Patient demographic data, clinical data ($n = 25$).

Variable	Mean (SD) range Number and %
Age (years)	56.5(8.5)
Gender (F/M)	6/19
Body weight (kg)	65.8(12)
Height (cm)	167(9)
ASA I/II	11/14
Duration of anesthesia in trendlinburg	7.8 h
Duration of anesthesia in supine (h)[a]	2.5 h
Total anesthesia time (h)	10.3 h
Duration in PACU (h)	4.5 h(0.6)
Estimated blood loss (ml)	700(120)
Amount of blood transfusion (units)	2–4
Amount of fresh frozen plasma (units)	4–6
Preoperative Hb (gm/dl)	9–13
No of patients needed blood transfusion	10(40%)
No of patients received nitroglycerine	12(48%)
No of patients received ephedrine	5(20%)
No of patients received lasix	15(60%)
Preoperative medical diseases	
Hypertension	5(20%)
Diabetes	5(20%)
COPD	6(24%)
Hepatic impairment	2(8%)
Renal impairment	2(8%)
Intra and postoperative complications	
Delayed extubation	3(12%)
Arrhythmias	3(12%)
Pulmonary embolism	1(4%)
Conjunctival edema	20(80%)
Surgical emphysema	2(10%)
Nausea and vomiting	1(4%)
ICU admission	4(16%)

[a] $n = 22$.

4. Discussion

This study revealed that robotic assisted radical cystectomy in the exaggerated Trendlenberg position is a challenging clinical setting to anesthetists due to the risks of position and long duration pneumoperitoneum.

Epidural drugs were used in robot assisted cystectomies only when the patient was made supine to construct urinary diversion.

The creation of PP and TT increased mean arterial blood pressure, the observed increase in arterial blood pressure can be explained by the increase of hydrostatic pressure caused by the tilting of the table, also is caused by increased cardiac output and systemic vascular resistance. O'Malley and colleagues showed that these changes are caused by the increase of intra-abdominal pressure which compresses the aorta and increases the after load [6]. Trans-esophageal Doppler measurements have shown a significant increase in stroke volume when patients are placed in the steep Trendelenburg position [7]. Humoral factors may also have a role [6]. Pneumoperitoneum and head-down position caused acute volume loading which causes acute elevation of CVP. Over subsequent hours, the MAP, CVP remained stable. After reassuming the supine position, both the MAP and CVP decreased significantly, but remained within acceptable ranges, we estimated the CPP from the MAP and CVP as the cerebral perfusion pressure (CPP) is determined by the difference between the mean arterial pressure (MAP) and the greater of the central venous pressure (CVP) and intracranial pressure (ICP) in the supine position [8]. So, in the situation of the steep trendelenburg position, the CVP is likely to be equivalent to, or greater than the ICP [8]. But since there was a greater increase in MAP than in CVP, the CPP increased significantly after institution of steep trendelenburg position, compared to the baseline value then decreased to base level gradually with sharp but transient decrease after assuming supine position due to the decrease of both MAP and CVP.

The CPP remained well above the lower limit for auto regulation of cerebral blood flow [9]. This coincides with results of Kalmar et al. [10].

Since the utility of $Pe'CO_2$ monitoring in the assessment and management of the adequacy of ventilation of patients with a

Table 2 Hemodynamic and pulmonary data, values are means and SD.

	T1	T2	T3	T4	T5	T6	T7[b]	T8	T9
HR (beats/m)	70(12)	73(9)	75(8)	72(8)	76(11)	79(9)	82(10)	79(9)	85(8)
MBP (mmHg)	77(12)	95(15)*	94 ± 13*	93(15)*	94(12*	75(11)[f]	84(13)	80(9)	80(13)
CVP (cm H_2O)	8(4)	20(6)*	23(5)*	22(7)*	22(6)*	15(6)*,[f]	12(4)	10(5)	8(6)
CPP	69(8)	75(9)*	71(9)	71(8)	72(9)	60(5)*,[f]	71(9)	70(8)	72(7)
$PaCO_2$	35(4)	42(4)*	48(6)*	52(6)*	54(4)*	45(6)*	43(4)	42(4)	40(5)
PH	7.43(0.04)	7.32*(0.02)	7.28*(0.02)	7.27*(0.03)	7.28*(0.03)	7.31(0.04)	7.34(0.02)	7.32(0.03)	(0.02)
HCO_3	24.6(0.2)	24.5(0.3)	23.6(0.2)	21.3(0.3)	22.2(0.6)	23.3(0.4)	23.6(0.4)	24.5(0.6)	25.3(0.7)
PaO_2/FiO_2	349(25)	298(32)	195*(45)	199*(33)	220*(43)	310(28)	320(33)	360(42)	360(36)
SO_2	100	98	96	94	94	97	99	99	99
Pplat cm H_2O	14(2)	20(3)*	26(4)*	28(4)*	29(4)*	18(6)[f]	16(4)	14(5)	
Compliance ml/cm H_2O	48(5)	32(4)*	24(6)*	23(5)*	23(7)*	30(7)*,[f]	40(5)[f]	45(7)	
Min. volume liter	6.7(1)	6.8(1.1)	7.5(1.2)*	7.8(1.1)*	8.2(1.2)*	8.1(0.9)*	7.1(1.2)	6.9(1.2)	

T1 – 10 min after induction, T2 – trendelengburg, T3 – inflation, T4 – 2 h robotic, T5 – 4 h robotic, T6 – after deflation and supine position, T7 – 2 h open supine surgery, T8 – before extubation, T9 – 2 h after recovery.

* Significant compared to after induction value.

[f] Significant compared to previous value ®$n = 22$.

[b] $n = 22$.

combined steep trendelenburg position and CO_2 peritoneum is less reliable as a predictor of $PaCO_2$ and has remained largely undefined as Alain et al. found that there is an underestimation by the $Pe'CO_2$ of the $PaCO_2$ at higher $Pe'CO_2$ levels [10]. Also, for patients with compromised cardiopulmonary function, the gradient between $PaCO_2$ and $PeCO_2$ may become high and unpredictable [11] So we used, direct estimation of $PaCO_2$ by arterial blood gas analysis to detect hypercarbia.

We reported a progressive significant increase $PaCO_2$ and was associated with respiratory academia, reaching its maximum reading before deflation, this agree with results of Attalah et al. [12].

The main factors contributing to an increase in $PaCO_2$ and respiratory acidosis are inadequate ventilation, increased dead space especially in patients with coexisting lung disease together with the peritoneal absorption of carbon dioxide and increased metabolic CO_2 production.

Although the paO_2/FiO_2 decreased modestly during steep trendelenburg position, SpO_2 remained well (above 95%) in all patients during the whole procedure.

The effects of pneumoperitoneum and trendlenburg position on pulmonary functions in other laparoscopic surgeries have been extensively studied [13]. It was reported that the decrease in compliance was immediately reversible upon abdominal deflation [14] but other studies reported that it may continue to hours after surgery [15,10]. In our study, we measured plateau pressure which is the pressure applied to small airways and alveoli. It is measured during an inspiratory pause on the ventilator. There was significant increase in plateau airway pressures after CO_2 insufflations and head down position. There was no significant additional increase in plateau pressure during the course of the operation. After reinstitution of the supine position, the plateau pressure returned to a level slightly above baseline values with reduction in compliance following CO_2 insufflations and remained stable during the trendelenburg period. After reinstitution of the supine position, a moderate residual loss of pulmonary compliance was observed as the reduction in compliance as related to basal reading continued up to two hours after deflation. This probably is caused by basal atelectasis, a residual cephalad displacement of the diaphragm and restriction in diaphragmatic mobility. This may be also explained by increased interstitial lung water resulting from exaggerated trendlenburg position. This transudate increases lung rigidity and decreases compliance [16].

The Minuit volume (MV) requirement increased soon after creation of the pneumoperitoneum, this can be due to increased dead space ventilation associated with increased intrathoracic pressure and decreased cardiac output. and the further increase during laparoscopy can be explained by a further absorption of CO_2, across the resection surfaces, the continuous increase of MV as for a few minutes after the release of the IAP may be due to increased metabolic CO_2 production or continuous absorption of CO_2 due to opening of occluded capillaries which were compressed by the high intra-abdominal pressure as some authors concluded that there is marginal further peritoneal area recruitment with higher IAP, and that compression of capillaries beneath the peritoneal surfaces probably limits further absorption of CO_2 at higher pressures and after release of pressure there is further absorption of CO_2 [17].

We reported mean blood loss of 700 ml which is higher than reported by other studies [19] and 10 patients (40%) needed blood transfusion, this may be because surgeons are in the early learning curve of the technique.

One patient developed A F after peritoneal inflation and trendlenburg position which resolve after deflation then very gradual inflation was done and the procedure was continued and two patients developed bradycardia which responded to atropine. Adverse events in the form of delayed extubation occurred in three patients, they were admitted to ICU one of them because of signs of airway obstruction from airway edema which resolved after 2 h (the patient received 100 mg hydrocorison). The other two due to delayed recovery, this may be due to cerebral edema because of the prolonged head down position, hampering awake and alert patient at the end of surgery [18], as in these two patients intra-corporeal urinary diversion was done while other patients were made supine at the end of radical cystectomy for about 2–3 h till completion of surgery. This allows chance to reverse some of the effects of increased IOP and cerebral edema compared to patients in whom surgery ends in trendelenburg position and not giving enough time to reverse these effects.

The presence of conjunctival edema indicates possible increase in IOP and ICP; we gave these patients 5 mg of lasix.

Hypoxemia occurred 2 h after extubation in one patient he was admitted to ICU where pulmonary embolism was diagnosed (spiral CT). He was managed with heparinization and non-invasive ventilation. Surgical emphysema occurred in two patients likely from abdominal ports with normal chest-X ray.

5. Conclusion

Robotic assisted radical cystectomy in the exaggerated trendlenberg position is a challenging clinical setting to anesthetists. Continuous monitoring intraoperatively and postoperatively with rapid interaction with anticipated events and potential risks is essential.

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