Journal of Anesthesia (2019) 33:103–107
https://doi.org/10.1007/s00540-018-2593-6

ORIGINAL ARTICLE

Efficacy of abdominal peripheral nerve block and caudal block during robot-assisted laparoscopic surgery: a retrospective clinical study

Satoko Noguchi[1] · Junichi Saito[1] · Kishiko Nakai[1] · Masato Kitayama[1] · Kazuyoshi Hirota[1]

Received: 12 May 2018 / Accepted: 30 November 2018 / Published online: 6 December 2018

Abstract

Purpose We retrospectively analyzed the efficacy of abdominal peripheral nerve block (PNB) and caudal block (CB) in patients undergoing robot-assisted laparoscopic radical prostatectomy (RARP).

Methods Patients who underwent elective RARP at our hospital (Jan. 2015–Sept. 2016) were enrolled. We reviewed the 188 patients' anesthesia charts and medical records and divided the patients into three groups based on the anesthesia used in their cases: 76 patients in the total intravenous anesthesia (TIVA) group, 51 patients in the TIVA + abdominal PNB group (TI-PB group), and 61 patients in the TIVA + abdominal PNB + CB (TI-PB-CB group). We compared the groups' amounts of anesthetic drug usage, anesthesia times, and the presence/absence of additional opioid administration in the recovery room.

Results The perioperative opioid use during anesthesia was significantly greater in the TIVA group than in the TI-PB-CB group. The total amount of muscle relaxant was significantly higher ($p < 0.001$) in the TIVA group than the TI-PB-CB group: 60.0 (50.0–70.0) mg vs. 50.0 (40.0–60.0) mg. Although there were no significant differences in the operation time, the frequency of the use of additional opioid administration was significantly higher ($p < 0.01$) in the TIVA group than the TI-PB group: 23.7% vs. 2.0%, respectively.

Conclusions Although there was no influence on the anesthesia time, the muscle relaxant dose and the perioperative amount of opioid use were significantly less in the combined PNB + CB group. Our analyses suggest that not only PNB but also CB was useful for perioperative management in RARP.

Clinical trial registration 2016-1059.

Keywords Peripheral nerve block · Caudal block · Muscle relaxant · Robotic surgery

Introduction

Laparoscopic surgery requires the patient's deep muscle relaxation so that the surgeon has a good view and sufficient space in the abdominal cavity. Deep muscle relaxation has reported to improve surgeons' satisfaction with the surgical space conditions [1] and to shorten operation times [2]. In addition, deep muscle relaxation makes it possible to perform a surgery using low pneumoperitoneum pressure, and thus alleviate some of the patient's postoperative pain [3]. Robot-assisted laparoscopic surgeries are being conducted more frequently nowadays; these surgeries can provide minimally invasion with early recovery. Robot-assisted laparoscopic surgeries also benefit from the patient's deep muscle relaxation.

The abdominal peripheral nerve block (PNB) has been performed mainly in lower abdominal surgeries to produce good muscle relaxation of the abdominal wall and postoperative analgesia [4]. A PNB may thus provide sufficient muscle relaxation with a lesser amount of muscle relaxant in the surgical field during robot-assisted laparoscopic surgeries. However, the beneficial effects of abdominal PNB on the surgical field during robotic surgery have not been elucidated. In addition, the caudal block (CB) was reported to reduce postoperative urinary catheter-induced discomfort [5]. Although epidural anesthesia has also been reported to reduce the necessary muscle relaxant dose [6], there is little information about the efficacy of a CB on the requirement

✉ Satoko Noguchi
nogusato1110@hirosaki-u.ac.jp

[1] Department of Anesthesiology, Hirosaki University Graduate School of Medicine, 5 Zaifu-cho, Hirosaki 036-8562, Japan

of a muscle relaxant in pelvic robot-assisted laparoscopic surgeries. We hypothesized that the combination of PNB and CB with general anesthesia reduced total amount of anesthetic agent even though during robotic surgery. Therefore, in the present study, we retrospectively investigated the efficacy of PNB and CB in patients who underwent a robot-assisted laparoscopic radical prostatectomy (RARP).

Methods

Study subjects

This was a retrospective observational study approved by the Ethics Committee of Hirosaki University Graduate School of Medicine (approval no. 2016 – 1059). Between January 2015 and September 2016, 191 patients underwent an elective RARP at our hospital. Patients with an insufficient or failed PNB were excluded from the analysis; we analyzed the cases of the remaining 188 patients based on their electronic medical records including anesthesia charts. We divided the patients into three groups based on the anesthesia used during their RARP: 76 patients received only total intravenous anesthesia (TIVA) (the TIVA group), 51 patients received TIVA with abdominal PNB (the TI-PB group), and 61 patients received TIVA with abdominal PNB and CB (the TI-PB-CB group). All patients in the TI-PB-CB group received an intra-abdominal instillation of 0.375% ropivacaine just before the removal of the abdominal ports, for the relief of postoperative visceral pain. Each anesthetic method was decided by daily anesthesia general manager who is in charge of all operating rooms. Thus, anesthesia method was dependent on each anesthetic manager's preference.

Anesthesia and PNB management

The following managements were obtained from the patients' medical records. Standard monitoring was used upon the patient's arrival in the operation room. Anesthesia was induced with propofol (0.5–1 mg/kg), remifentanil (0.2–0.5 μg/kg/min), ketamine (0.5–1 mg/kg) and rocuronium (0.6–1 mg/kg), and maintained with propofol (2–8 mg/kg/h) and remifentanil (0.025–0.5 μg/kg/min) with a target bispectral index (BIS) value of 40–60 (monitored with a BIS-XP® system, Aspect Medical Systems, Leiden, The Netherlands). And additional ketamine (10–50 mg) was intermittently administered for preventing somatic pain by each anesthesiologist. Vasoactive agents such as ephedrine, phenylephrine, and atropine were intermittently given to maintain the mean arterial pressure at > 60 mmHg and the heart rate between 40 and 100 beats/min. The patient's lungs were mechanically ventilated to maintain the end-tidal carbon dioxide ($EtCO_2$) at 30–40 mmHg using the pressure-controlled mode with peak inspiratory pressure < 25 cm H_2O. During the surgery, intermittent 10-mg rocuronium was administered when it was necessary, for example, to provide sufficient surgical space, preventing body movement or cough reflex according to vital sigh change or train-of-four (TOF) count. After the surgery, sugammadex was administered if needed (e.g., when the TOF ratio was < 0.9). The above management was done by each patient's anesthesiologist.

In the TI-PB group, a subcostal transversus abdominis plane block and a lower abdominal rectus sheath block were performed after the induction of general anesthesia, using 30–50 mL of 0.3–0.375% ropivacaine. In the TI-PB-CB group, a CB was also performed, using 10–15 mL of 0.3–0.375% ropivacaine after an abdominal PNB. The total dose of ropivacaine for CB and abdominal PNB was limited to 3 mg/kg, and all procedures were performed with ultrasound guidance. In the TI-PB-CB group, a local intra-abdominal instillation of 40 mL of 0.375% ropivacaine was administered by each surgeon after pneumoperitoneum was achieved.

Postoperative analgesia

Fentanyl and/or morphine was injected intravenously as needed to control the postoperative pain of each patient. Acetaminophen or flurbiprofen was also administered if it was necessary. All patients used intravenous patient-controlled analgesia (14–18 μg/hr of fentanyl or 0.6–0.8 mg/hr of morphine based) until postoperative day 2.

Data collection and definitions

The following data were collected from each patient's medical record: age, body weight, height, body mass index (BMI), ASA physical status, value of preoperative prostate-specific antigen, the D'Amico risk classification, neoadjuvant chemotherapy, the total amounts of anesthetic drugs (propofol, remifentanil, ketamine, morphine, rocuronium), pneumoperitoneum time, operation time, anesthesia time, postanesthetic care unit (PACU) management, and deviation from the RARP Path. Fentanyl 200 μg was converted into morphine 10 mg [7] in patients who had been administered fentanyl as postoperative analgesic. All patients were managed by the clinical path known as the "RARP Path" in our hospital and hospitalized for 15 days.

Outcomes and statistical analyses

Primary outcome of this study was the difference of total amount of anesthetic agent between three groups and secondary outcome were the differences of intra-operative data and PACU management. To compare the three patient

groups' total amount of anesthetic agents, anesthesia time, and presence/absence of additional opioid administration in the PACU, we performed a one-way analysis of variance (ANOVA) and used the Kruskal–Wallis test and Fisher's exact test. We also used Tukey's test and Dunn's test as post hoc tests. The data analyses were performed with GraphPad Prism 6 software (GraphPad Software, San Diego, CA). The data are presented herein as the mean ± SD, median [25% quartile–75% quartile] or the n (%). A p-value < 0.05 was considered significant.

Results

The patient demographics are summarized in Table 1. There were no significant differences in demographics among the three groups (TIVA, TI-PB, and TI-PB-CB). The total amounts of anesthesia-related agents used are shown in Table 2. Regarding the total amount of anesthetic agents, the TIVA group showed significantly higher doses of propofol compared to the TI-PB-CB group, and significantly higher doses of ketamine compared to both the TI-PB group and the TI-PB-CB group. The total dose of opioids such as remifentanil and morphine were significantly higher in the TIVA group compared to those in the TI-PB and TI-PB-CB groups. The rocuronium dose was also significantly higher in the TIVA group compared to those in the TI-PB and TI-PB-CB groups, although the rate of sugammadex requirement did not differ among groups. Therefore, the patients without regional anesthesia required more anesthetic agents, analgesics, and muscle relaxant. The morphine dose was significantly lower in the TI-PB group than in the TI-PB-CB group.

As shown in Table 3, the intraoperative blood loss was significantly less in the TI-PB-CB group compared to that in the TIVA group. The percentage of patients needing additional opioids postoperatively was significantly higher in the TIVA group than in the TI-PB group. There were no significant between-group differences among the other factors shown in Table 3.

Discussion

Our analyses revealed that regional anesthesia such as PNB and CB significantly reduced the total amount of anesthetic agents in patients who underwent a RARP that involved the

Table 1 Patient demographics in this study

Variable	TIVA ($n=76$)	TI-PB ($n=51$)	TI-PB-CB ($n=61$)	p value
Age, years	67.9 ± 6.1	67.5 ± 5.6	67.3 ± 5.2	0.776
Height, cm	165.2 ± 5.5	164.5 ± 6.7	164.6 ± 5.6	0.768
Weight, kg	66.9 ± 8.4	64.5 ± 9.2	63.7 ± 9.1	0.079
BMI, kg/m^2	24.5 ± 2.8	23.8 ± 2.7	23.5 ± 3.0	0.086
ASA-PS I/II/III, n (%)	0/74/2 (0.0/97.4/2.6)	1/49/1 (2.0/96.0/2.0)	1/60/0 (1.6/98.4/0.0)	0.570
Preop PSA, ng/mL	7.16 [5.08–10.62]	7.31 [5.43–10.50]	8.70 [6.01–14.30]	0.102
D'Amico classification L/I/H, n (%)	6/23/47 (7.9/30.3/61.8)	2/21/28 (3.9/41.2/54.9)	1/20/40 (1.6/32.8/65.6)	0.341
Neoadjuvant CT n (%)	50 (65.8)	30 (58.8)	39 (63.9)	0.721

Data are mean ± SD, median [25% quartile–75% quartile].

Preop preoperative, *CT* chemotherapy

Table 2 Total doses of general anesthesia-related agents used

Variable	TIVA ($n=76$)	TI-PB ($n=51$)	TI-PB-CB ($n=61$)	p value
Propofol, g	1.23 [1.00–1.40]	1.10 [0.81–1.40]	1.11 [0.84–1.26]‡	0.024
Remifentanil, mg	2.75 [2.50–3.25]	2.00 [1.75–2.35]††††	1.85 [1.53–2.25]‡‡‡‡	< 0.001
Ketamine, mg	110 [100–130]	100 [70–120]†††	90 [80–100]‡‡‡‡	< 0.001
Rocuronium, mg	60.0 [50.0–70.0]	55.0 [50.0–65.0]	50.0 [40.0–60.0]‡‡‡‡	< 0.001
Morphine, mg	10.0 [10.0–14.7]	10.0 [10.0–10.0]†	10.0 [10.0–10.0]‡‡‡‡§	< 0.001
Acetaminophen, n (%)	64 (84.2)	32(62.7)	18 (29.5) ‡‡	< 0.001
Sugammadex, n (%)	5 (6.6)	5 (9.8)	0 (0)	0.058

Data are mean ± SD, median [25% quartile-75% quartile]

$^{\dagger}p<0.05$, $^{\dagger\dagger}p<0.01$, $^{\dagger\dagger\dagger}p<0.005$, $^{\dagger\dagger\dagger\dagger}p<0.001$ TIVA vs. TI-PB., $^{\ddagger}p<0.05$, $^{\ddagger\ddagger}p<0.01$, $^{\ddagger\ddagger\ddagger}p<0.005$, $^{\ddagger\ddagger\ddagger\ddagger}p<0.001$, TIVA vs. TI-PB-CB., $^{\S}p<0.05$, TI-PB vs. TI-PB-CB

Table 3 Intra- and post-operative characteristics in this study

Variable	TIVA ($n=76$)	TI-PB ($n=51$)	TI-PB-CB ($n=61$)	p-value
Requiring increased PP, n (%)	7(9.2)	3 (5.9)	2 (3.3)	0.391
Pneumoperitoneum time, min	138.5 [120.8–157.0]	136.0 [122.0–154.0]	129.0 [116.5–152.0]	0.234
Duration of operation, min	168.0 [150.0–183.0]	162.0 [148.0–179.0]	152.0 [141.0–181.0]	0.121
Anesthesia time, min	230 [208–245]	238 [212–256]	230 [212–266]	0.628
Fluid volume, mL	1000 [800–1200]	1000 [800–1400]	1100 [900–1445]‡	0.055
Blood loss, g	50 [15–75]	25 [5–50]	25 [5–50] ‡‡	0.013
Urine volume, mL	72 [30–150]	40 [20–100]	50 [33–100]	0.110
PACU management, n (%)				
Postop opioid requirement	18 (23.7)	1 (2.0)††	5 (8.2)	<0.001
Shivering	2 (2.6)	0 (0.0)	4 (6.6)	0.179
Agitation	7 (9.2)	1 (2.0)	1 (1.6)	0. 090
Others	1 (1.3)	2 (3.9)	3 (4.9)	0.441
Deviation of RARP Path	12 (15.8)	11 (21.6)	6 (9.8)	0.238

Data are median [25% quartile-75% quartile]

†p <0.05, ††$p<0.01$, †††$p<0.005$, ††††$p<0.001$ TIVA vs. TI-PB. ‡$p<0.05$, ‡‡$p<0.01$, ‡‡‡$p<0.005$, ‡‡‡‡$p<0.001$, TIVA vs. TI-PB-CB

PACU postanesthetic care unit, *PP* pneumoperitoneum, *RARP* robot-assisted laparoscopic radical prostatectomy

administration of total intravenous anesthesia (TIVA). Similar to the present study, Kokulu and colleagues [8] reported that the amount of desflurane used was significantly lower in patients with PNB compared to those without PNB. PNB may thus be cost-effective.

It was also reported that the use of a PNB could decrease the early perioperative opioid usage and shorten the length of hospitalization [9] because preemptive analgesia can be enforced using PNB as one of the multimodal analgesic agents [10] and postoperative analgesia can be alleviated by blocking harmful stimulation [11]. Indeed, in our patient series, the use of PNB significantly reduced the perioperative analgesic consumption although the length of hospital stay did not change.

In the present patients, the combination of PNB with CB resulted in a significantly lower use of rocuronium as well as intraoperative opioids. In laparoscopic cholecystectomy, it was reported that the use of a deep muscle relaxant improves the surgical field [12, 13] and decreases the duration of the operation [2]. Among children undergoing urologic laparoscopic or robot-assisted laparoscopic procedures, the total amount of intra-operative opioids in the combination CB group was significantly lower compared to that in the combination transversus abdominis plane block group [14]. However, there is little information available regarding muscle relaxants' effect when used with a CB in patients undergoing pelvic surgery other than pediatric populations [15].

The pelvic floor muscle group is involved in the increase of abdominal pressure in the pelvis, which is dominated by the 4th and 5th sacral nerves [16]. In the present study, we investigated patients who underwent a RARP, and the muscle relaxants' effect with CB may be involved in securing the space inside the pelvic cavity. Therefore, the uses of not only intraoperative opioids but also muscle relaxants were significantly reduced in the patients who received both a PNB and CB compared to those with only a PNB. Therefore, CB may provide beneficial effects in patients undergoing pelvic surgery.

As maximum dose of ropivacaine is 3 mg/kg, we could use 0.375% ropivacaine up to 0.8 ml/kg (= more than 40 ml in all patients' body weight > 50 kg in the present study) for CB and abdominal PNB. Previous reports suggested that intra-abdominal instillation could reduce postoperative analgesia which may be due to relief of visceral pain [17, 18]. In addition, from our previous study [19], we could estimate that intra-abdominal instillation of 40 mL of 0.375% ropivacaine just before abdominal closure must be safe. In this previous study [19], maximal plasma concentrations of ropivacaine were 1.00±0.26 (SD) μg/mL in rectus sheath block with 0.375% ropivacaine 20 ml before surgery followed by intra-abdominal instillation with 0.5% ropivacaine 20 ml just before abdominal closure, whose plasma concentration was much lower than its toxic threshold of 2.2 μg/mL [20]. Since the administration interval of ropivacaine seemed sufficient for disappearance of ropivacaine in the plasma, the maximal ropivacaine plasma concentration after intra-abdominal instillation with 0.375% ropivacaine 40 mL may not exceed the toxic threshold. Indeed, anesthetic records suggested that no patients revealed local anesthetic-induced toxic symptoms.

Our study has several limitations, including its retrospective, single-center design. Since each anesthesiologist has

known the presence or absence of PNB and CB, there might be some prejudice that the patients did not need much sedative and analgesia. In addition, since we did not use TOF monitor routinely during surgery, additional administration of muscle relaxant had been done in accordance with subjective factors of each anesthesiologist or surgeon's request. Although anesthesiologist seemed to sufficiently administer additional muscle relaxant in some cases, many cases might not maintain deep muscle relation. Thus, some information and selection bias could not exclude completely. Finally, we need to consider whether these statistically significant differences have clinically meaningful. As anesthetic management was done by each patient's anesthesiologist without any protocol, further prospective study will be required to evaluate the effect of peripheral nerve block on the condition of surgical field.

In conclusion, the present data suggest that the use of an abdominal peripheral nerve block reduces the intraoperative opioid usage, and the use of a caudal block may provide an additional muscle relaxant effect on the pelvic floor muscle group. The administration of both an abdominal PNB and a CB may have beneficial effects in patients undergoing a robot-assisted laparoscopic radical prostatectomy under total intravenous anesthesia.

Compliance with ethical standards

Conflict of interest The authors declare no conflicts of interest.

References

1. Martini CH, Boon M, Bevers RF, Aarts LP, Dahan A. Evaluation of surgical conditions during laparoscopic surgery in patients with moderate vs deep neuromuscular block. Br J Anaesth. 2014;112:498–505.
2. Koo BW, Oh AY, Seo KS, Han JW, Han HS, Yoon YS. Randomized clinical trial of moderate versus deep neuromuscular block for low-pressure pneumoperitoneum during laparoscopic cholecystectomy. World J Surg. 2016;40:2898–903.
3. Hua J, Gong J, Yao L, Zhou B, Song Z. Low-pressure versus standard-pressure pneumoperitoneum for laparoscopic cholecystectomy: a systematic review and meta-analysis. Am J Surg. 2014;208:143–50.
4. Schleich CL. Schmerzlose Operationen. 4th ed. Berlin: Springer; 1899, pp. 240–8.
5. Tsuchiya M, Kyoh Y, Mizutani K, Yamashita J, Hamada T. Ultrasound-guided single shot caudal block anesthesia reduces postoperative urinary catheter-induced discomfort. Minerva Anestesiol. 2013;79:1381–8.
6. Agarwal A, Pandey R, Dhiraaj S, Singh PK, Raza M, Pandey CK, Gupta D, Choudhury A, Singh U. The effect of epidural bupivacaine on induction and maintenance doses of propofol (evaluated by bispectral index) and maintenance doses of fentanyl and vecuronium. Anesth Analg. 2004;99:1684–8.
7. Knotkova H, Fine PG, Portenoy RK. Opioid rotation: the science and the limitations of the equianalgesic dose table. J Pain Symptom Manage. 2009;38:426–39.
8. Kokulu S, Bakı ED, Kaçar E, Bal A, Şenay H, Üstün KD, Yılmaz S, Ela Y, Sıvacı RG. Effect of transversus abdominis plane block on cost of laparoscopic cholecystectomy anesthesia. Med Sci Monit. 2014;20:2783–7.
9. Calì Cassi L, Biffoli F, Francesconi D, Petrella G, Buonomo O. Anesthesia and analgesia in breast surgery: the benefits of peripheral nerve block. Eur Rev Med Pharmacol Sci. 2017;21:1341–5.
10. Vadivelu N, Mitra S, Schermer E, Kodumudi V, Kaye AD, Urman RD. Preventive analgesia for postoperative pain control: a broader concept. Local Reg Anesth. 2014;7:17–22.
11. Kissin I. Preemptive analgesia. Why its effect is not always obvious. Anesthesiology. 1996;84:1015–9.
12. Staehr-Rye AK, Rasmussen LS, Rosenberg J, Juul P, Lindekaer AL, Riber C, Gätke MR. Surgical space conditions during low-pressure laparoscopic cholecystectomy with deep versus moderate neuromuscular blockade: a randomized clinical study. Anesth Analg. 2014;119:1084–92.
13. Barrio J, Errando CL, San Miguel G, Salas BI, Raga J, Carrión JL, García-Ramón J, Gallego J. Effect of depth of neuromuscular blockade on the abdominal space during pneumoperitoneum establishment in laparoscopic surgery. J Clin Anesth. 2016;34:197–203.
14. Faasse MA, Lindgren BW, Frainey BT, Marcus CR, Szczodry DM, Glaser AP, Suresh S, Gong EM. Perioperative effects of caudal and transversus abdominis plane (TAP) blocks for children undergoing urologic robot-assisted laparoscopic surgery. J Pediatr Urol. 2015;11:121.e1–7.
15. Kaya Z, Süren M, Arici S, Karaman S, Tapar H, Erdemir F. Prospective, randomized, double-blinded comparison of the effects of caudally administered levobupivacaine 0.25% and bupivacaine 0.25% on pain and motor block in children undergoing circumcision surgery. Eur Rev Med Pharmacol Sci. 2012;16:2014–20.
16. Moore KL, Dalley AF, Agur AMR. Clinically Oriented Anatomy. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2010.
17. Kahokehr A, Sammour T, Zargar Shoshtari K, Taylor M, Hill AG. Intraperitoneal local anesthetic improves recovery after colon resection: a double-blinded randomized controlled trial. Ann Surg. 2011;254:28–38.
18. Goldstein A, Grimault P, Henique A, Keller M, Fortin A, Darai E. Preventing postoperative pain by local anesthetic instillation after laparoscopic gynecologic surgery: a placebo-controlled comparison of bupivacaine and ropivacaine. Anesth Analg. 2000;91:403–7.
19. Yakoshi C, Hashimoto H, Niwa H, Kitayama M, Kudou T, Kudou M, Hirota K. Analgesic efficacy and clinical safety of intraperitoneal instillation combined with rectus sheath block using ropivacaine for pain relief after laparoscopic gynecological surgery. Masui. 2014;63:296–302.
20. Brydone AS, Souvatzoglou R, Abbas M, Watson DG, McDonald DA, Gill AM. Ropivacaine plasma levels following high-dose local infiltration analgesia for total knee arthroplasty. Anaesthesia. 2015;70:784–90.