Original Article

ปัจจัยที่ใช้ทำนายความต้องการใช้ยาระงับปวดเฟนตานิลในระหว่างและหลังผ่าตัดทางระบบทางเดินปัสสาวะในเด็ก@

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Predictive Factors of Perioperative Fentanyl Consumption During Urologic Surgery in Children.

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Songkla Med J 2010;28(6):305-316

บทคัดย่อ:

วัตถุประสงค์: การได้รับยาระงับปวดในระหว่างผ่าตัดเป็นปัจจัยสำคัญที่อาจทำให้เกิดภาวะแทรกซ้อนหลังผ่าตัดในเด็กได้ การศึกษาครั้งนี้ได้ตั้งสมมุติฐานว่าเทคนิคการระงับความรู้สึกเป็นปัจจัยทำนายความต้องการยาระงับปวดเฟนตานิลในระหว่างผ่าตัด พร้อมได้วิเคราะห์ปัจจัยอื่นๆ ที่มีผลต่อความต้องการเฟนตานิลในระหว่างผ่าตัดและที่ห้องพักฟื้น

วัสดุและวิธีการ: การศึกษานี้ได้ผ่านการพิจารณาจากคณะกรรมการจริยธรรมในมนุษย์ของโรงพยาบาลสงขลานครินทร์ โดยเก็บข้อมูลย้อนหลังจากใบบันทึกการให้ยาระงับความรู้สึกในผู้ป่วยเด็กอายุ 0-9 ปี จำนวน 147 รายที่มาผ่าตัดทางระบบทางเดินปัสสาวะตั้งแต่เดือนมกราคม พ.ศ. 2548 ถึง เดือนธันวาคม

@This research was funded by Faculty of Medicine, Prince of Songkla University
The abstract was presented as a poster presentation in The XXVIII Annual European Society of Regional Anaesthesia (ESRA) Congress at Salzburg, Austria in September 9-12, 2009
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พ.ศ. 2550 ตัวแปรหลักที่นำมาวิเคราะห์เพื่อหาปัจจัยดังกล่าวได้แก่ อายุ น้ำหนัก เพศ เทคนิคการระงับความรู้สึก ชนิดและระยะเวลาของการผ่าตัด ชนิดของยาระงับความรู้สึก ปัจจัยทำนายความต้องการเฟนตานิลถูกวิเคราะห์โดยสถิติ univariate และ multivariate logistic regression

ผลการศึกษา: ความต้องการเฟนตานิลระหว่างผ่าตัดมีความสัมพันธ์กับเทคนิคการให้ยาระงับความรู้สึกและชนิดของการผ่าตัด (p=0.013) กล่าวคือ การให้ยาระงับความรู้สึกแบบทั้งตัวร่วมกับการฉีดยาระงับความรู้สึกเฉพาะที่ caudal หรือที่เส้นประสาท ilioinguinal ลดแนวโน้มความต้องการเฟนตานิล > 1 มคก. ต่อ กก. อย่างมีนัยสำคัญทางสถิติเมื่อเทียบกับการให้ยาระงับความรู้สึกแบบทั้งตัวอย่างเดียว (the adjusted odd ratios 95% confidence interval เท่ากับ 0.02 (0.01-0.09) และ 0.06 (0.02-0.22) ตามลำดับ, p<0.001) พบแนวโน้มความต้องการเฟนตานิลที่ห้องพักฟื้นในเด็กผู้หญิง (p=0.04) ผู้ป่วยที่ได้รับการนำสลบด้วยยาพรอบพอฟอลและซีโวฟลูเรน (p=0.002) และรักษาระดับสลบด้วยซีโวฟลูเรน (p=0.04)

สรุป: เทคนิคการระงับความรู้สึกและชนิดของการผ่าตัด เป็นปัจจัยทำนายความต้องการเฟนตานิลในระหว่างผ่าตัด ส่วนปัจจัยทำนายความต้องการเฟนตานิลที่ห้องพักฟื้น ได้แก่ เพศและชนิดของยาระงับความรู้สึก

คำสำคัญ: การผ่าตัดทางระบบทางเดินปัสสาวะในผู้ป่วยเด็ก, ความต้องการยาระงับปวดเฟนตานิล, ปัจจัยทำนาย

Abstract:

Objective: Perioperative opioid consumption is one important factor that can lead to postoperative complications following surgery in pediatric patients. Our hypothesis is the techniques of anesthesia are predictive factors for intraoperative fentanyl consumption. We have also tried to explore which of the existing factors might be associated with intraoperative and the post-anesthetic care unit (PACU) fentanyl consumption in children who undergo elective, urologic surgery.

Material and methods: After approval from the Ethics Committee of Songklanagarind Hospital, the anesthetic charts were retrospectively reviewed in 147 children, aged 0-9 years, from January, 2005 to December, 2007. The variables considered were age, weight, sex, technique of anesthesia, type of surgery, duration of surgery and type of anesthetic agent. Perioperative fentanyl consumption was analyzed by univariate and multivariate logistic regression analysis.

Results: Intraoperative fentanyl consumption was associated with the anesthetic technique and type of surgery (p=0.013). General anesthesia combined with caudal or ilioinguinal nerve block decreased the probability of fentanyl required > 1 mcg/kg compared to general anesthesia alone with adjusted odd ratios (95% confidence interval) of 0.02 (0.01-0.09) and 0.06 (0.02-0.22) respectively (p<0.001). PACU fentanyl consumption was significantly more likely to require in female cases (p = 0.04), in cases induced with propofol and sevoflurane (p=0.002) and in cases with sevoflurane anesthesia (p=0.04).

Conclusions: The predictive factors of intraoperative fentanyl consumption were the anesthetic technique and type of surgery. The predictive factors of PACU fentanyl consumption were sex and anesthetic agent.

Key words: fentanyl consumption in children, predictive factors, urologic surgery

Introduction

Urologic surgery in children is mostly performed as a day-case surgery. The anesthetic technique is selected with the objectives of minimizing pain, enabling a fast recovery, early urination and an early discharge from the hospital. Children who need more opioids perioperatively may encounter unwanted side effects such as nausea, vomiting, urinary retention and respiratory depression as dose-dependent side effects.[1,2] Anesthetic techniques or factors which encourage less opioid consumption will relate to lower side effects and a faster discharge from the post-anesthetic care unit (PACU). Regional anesthesia, such as a caudal block or ilioinguinal nerve block, combined with general anesthesia has been found to provide a lower pain score at the PACU, a faster recovery and less adverse events such as nausea, vomiting, and respiratory events when compared to general anesthesia without regional blocks in urologic surgery in children.[3-7]

However, combined general and regional anesthesia in children is not the routine practice in our hospital because performing regional anesthesia is time-consuming and its efficiency also depends on the technique and experience of the anesthesiologist. Moreover, some articles have reported serious complications related to caudal and ilioinguinal nerve block such as sacral osteomyelitis and bowel injuries.[3,4] The primary objective of the study was to find out if the different techniques of anesthesia were predictive factors of intraoperative fentanyl consumption during urologic surgery in children in Songklanagarind Hospital. The secondary objectives were to look for the other predictive factors such as the children's characteristics, the type of surgery, the duration of surgery and the type of anesthetic agent which might be associated with intraoperative and PACU fentanyl consumption, and to examine any adverse effects related to intraoperative fentanyl consumption.

Materials and methods

After approval from the Ethics Committee of Songklanagarind Hospital at Prince of Songkla University in Thailand, the anesthetic records of 147 children who had undergone elective urologic surgery from January, 2005 to December, 2007 were reviewed, with the following inclusion and exclusion criteria. The inclusion criteria included children aged 0-9 years who received general anesthesia with, or without, a combined caudal block or ilioinguinal nerve block and elective cases including both surgical day-cases and inpatient cases. The exclusion criteria included anesthesia technique was regional anesthesia alone and children received local anesthetic by surgeon intraoperatively. We chose patient aged 0-9 years old because age > 9 years old was concerned anatomical change like adult and not be able to perform a caudal block. We compared the anesthetic technique between general anesthesia and combined general with regional anesthesia because combined technique provides less postoperative pain, faster recovery and less opioid related-side effects according to the literatures.[3-7] The child's age, sex, inpatient or outpatient status, American Society of Anesthesiologists (ASA) classification, technique of anesthesia, type of surgery, duration of surgery and type of anesthetic agent were collected to be

analysed as possible predictive factors of intraoperative and PACU fentanyl consumption.

Before induction of general anesthesia, fentanyl (0.5-1 mcg/kg) was routinely given to the children. The technique of anesthesia either general anesthesia alone or combined with regional anesthesia was decided by the attending anesthesiologist. Combined general anesthesia and regional anesthesia cases were done by an anesthesiologist with at least one year of experience. Regional anesthesia was performed after general anesthesia was conducted. Airway management was achieved by facemask ventilation, laryngeal mask airway ventilation or endotracheal tube intubation. Caudal block was performed using the loss of resistance technique using 0.25% bupivacaine with adrenaline ((5 mcg/ml) 0.5-1 ml/kg) depending on the type of operation. Ilioinguinal nerve block was performed by fanwise injection, 2 cm medial to the upper aspect of the anterior-superior, iliac spine (ASIS) by using 0.25% bupivacaine (0.5 ml/kg).[8] After the surgical incision, fentanyl (0.5 mcg/kg) was given intravenously every 30-60 minutes if the blood pressure or heart rate increased to more than 20% of baseline. After the operation was finished, fentanyl (0.5 mcg/kg) was given intravenously every 10-15 minutes if child had moderate to severe pain as assessed by the PACU anesthetist nurses. Oral analgesic drugs such as paracetamol (20 mg/kg) and/or ibuprofen (10 mg/kg) were also given to children who still had moderate to severe pain after the first or second doses of fentanyl. Intraoperative and PACU complications related to intraoperative fentanyl consumption were recorded.

Statistical analysis

Statistical analysis was performed with the R program version 2.3.1. Descriptive statistics were computed for all variables and included frequency, proportion, mean ± SD and median (range). Univariate analysis was performed using the chi-squared test or Fisher's exact test for categorical data to analyze the association between the independent variables - children's age, sex, inpatient or outpatient status, ASA classification, technique of anesthesia, type of surgery, duration of surgery, type of anesthetic agent, perioperative complications and the dependent variable of fentanyl consumption. To look for any the association between the potential predictive factors and intraoperative fentanyl consumption, the dependent variable was the fentanyl dosage (> 1 mcg/kg or ≤ 1 mcg/kg (as a control)). We considered fentanyl ≤ 1 mcg/kg as the low dose fentanyl group and fentanyl > 1 mcg/kg as the higher dose group. For identification of predictive factors of PACU fentanyl consumption, the outcome variable was any PACU fentanyl requirement compared with no PACU fentanyl requirement (as a control). Categorical data with a significance level of $p \leq 0.2$ in univariate analysis were then included in multivariate logistic regression analysis for the intraoperative and PACU fentanyl consumption. The results were reported as adjusted odds ratios (OR) and 95% confidence intervals (CI). The statistical significance of each variable in the model was assessed by the likelihood ratio test. Model refinement was done by backward elimination until only variables with a significance of $p<0.05$ remained.

As far as could be ascertained, no studies had reported on the amounts of intraoperative fentanyl consumption in different techniques of general anesthesia. Therefore, a pilot study was conducted by retrospectively-reviewing anesthetic records between January, 2006 and December, 2007 in 90 children who were divided into 3 groups-general anesthesia alone (30), general anesthesia with a caudal block (30) and general anesthesia with an ilioinguinal nerve block (30) - to get some baseline data on the differences in intraoperative fentanyl consumption among the anesthetic techniques. Sample-size calculation was based on the differences of intraoperative fentanyl requirements between general anesthesia and combined general with regional anesthesia group. Based on the pilot study the estimated sample sizes were 20 children per group for comparison between general anesthesia alone and combined general anesthesia with caudal block, and 40 children per group for comparison between general anesthesia alone and combined general anesthesia with an ilioinguinal nerve block to provide a power of 80% and a type I error of 5%. To consider the sample size based on intraoperative fentanyl consumption comparison between general anesthesia alone and combined general anesthesia with an ilioinguinal nerve block, we need at least 10 more children in each group. Therefore, we extended the review back one more year from January to December, 2005 to include another 57 children; finally 147 children were included in total - general anesthesia alone (52), general anesthesia with caudal block (51) and general anesthesia with ilioinguinal nerve block (44).

Results

One hundred and forty-seven children were enrolled in the study between January 2005 and December 2007. The mean age was 40.29±28.09 months, 88.4% were male and 11.6% female, 64.6% were inpatients and 35.4% were outpatients. The anesthetic techniques used in the study were general anesthesia alone, general anesthesia with a caudal block and general anesthesia with an ilioinguinal nerve block; the rates of technique were 35.4, 34.7 and 29.9%, respectively. The most common surgery was herniotomy at 54.4%, followed by orchidopexy and hypospadia repair at 23.8 and 21.3%, respectively (Table 1).

Table 1 Demographic data

Patient characteristic	Results (n=147)
Age (months), mean (SD)	40.29 (28.09)
Sex	
Male, n (%)	130 (88.4)
Female, n (%)	17 (11.6)
Body weight (kg), mean (SD)	14.46 (6.32)
Patient	
Inpatient, n (%)	95 (64.6)
Outpatient, n (%)	52 (35.4)
ASA classification, n (%)	
1	68 (46.3)
2	77 (52.4)
3	2 (1.4)
Anesthetic technique, n (%)	
GA	52 (35.4)
GA with caudal block	51 (34.7)
GA with ilioinguinal nerve block	44 (29.9)
Type of surgery, n (%)	
Herniotomy	80 (54.4)
Orchidopexy	35 (23.8)
Hypospadia repair	32 (21.8)
Duration of surgery (min), median (range)	75 (30-340)

GA = General anesthesia

Univariate and multivariate analysis of intraoperative fentanyl consumption

Crude odds ratios (OR) and 95% CI were calculated for each of the 10 variables. Only three variables had crude OR with p≤0.2 as measured by univariate analysis, namely the technique of anesthesia, type of surgery and duration of surgery. After being submitted to multivariate analysis, two variables, technique of anesthesia and type of surgery, remained statistically significant (Table 2). When comparing the special techniques of anesthesia with general anesthesia alone, those that combined general anesthesia with a caudal block or with an ilioinguinal nerve block had a protective effect, that is they were less likely to require the higher intraoperative fentanyl consumption; the adjusted OR (95% CI) were 0.02 (0.01-0.09) and 0.06 (0.02-0.22), respectively (p<0.001). Comparing herniotomy surgery with orchidopexy and hypospadia repair, orchidopexy and hypospadia repair were more likely to need higher dose of fentanyl; the adjusted OR (95% CI) were 4.07 (1.3-12.78) and 3.91 (1.17-13.08), respectively (p=0.013). A duration of surgery > 3 hours was associated with a higher dose of fentanyl compared to those undergoing a surgery < 1 hour, but this was not statistically significant; the adjusted OR (95% CI) was 2.1 (0.25-17.62) (p=0.48). Intraoperative fentanyl consumption was not associated with a patient's characteristics (patient's age, sex, inpatient or outpatient status, ASA classification) or with the anesthetic agent.

Table 2 Univariate and multivariate analysis to determine predictive factors of intraoperative fentanyl consumption

Variable	Crude OR (95%CI)	P*	Adjusted OR (95% CI)	P**
Anesthetic technique				
GA	1	<0.001	1	<0.001
GA with caudal block	0.04 (0.01-0.13)		0.02 (0.01-0.09)	
GA with ilioinguinal nerve block	0.06 (0.02-0.21)		0.06 (0.02-0.22)	
Type of surgery				
Herniotomy	1	0.16	1	0.013
Orchidopexy	2.16 (0.91-5.06)		4.07 (1.30-12.78)	
Hypospadia repair	1.64 (0.70-3.85)		3.91 (1.17-13.08)	
Duration of surgery (min)				
0-60	1	0.23	1	0.48
60-120	0.93 (0.44-1.98)		1.01 (0.38-2.74)	
120-180	0.29 (0.07-1.10)		0.43 (0.08-2.17)	
>180	1.43 (0.25-8.23)		2.10 (0.25-17.62)	

GA = General anesthesia

*P-values based on chi-squared test

**P-values based on likelihood ratio test

Table 3 Univariate and multivariate analysis to determine predictive factors of PACU fentanyl consumption

Variable	Crude OR (95%CI)	P*	Adjusted OR (95% CI)	P**
Sex				
Male	1	0.007	1	0.04
Female	5.20 (1.6-16.84)		4.00 (1.04-15.48)	
Patient status				
Inpatient	1	<0.001	1	0.48
Outpatient	3.76 (1.85-7.66)		1.42 (0.54-3.70)	
ASA classification				
1	1	0.13	1	0.66
2	0.51 (0.26-0.99)		0.89 (0.39-2.06)	
3	0.94 (0.06-15.70)		3.64 (0.16-84.24)	
Anesthetic technique				
GA	1	0.02	1	0.14
GA with caudal block	0.35 (0.15-0.8)		0.37 (0.13-1.03)	
GA with ilioinguinal nerve block	0.93 (0.41-2.07)		0.82 (0.32-2.1)	
Induction agent				
Propofol	1	<0.001	1	0.002
Thiopental	0.20 (0.04-0.87)		0.13 (0.02-0.65)	
Sevoflurane	1.49 (0.42-5.21)		0.77 (0.19-3.14)	
Volatile agent				
Sevoflurane	1	0.02	1	0.04
Isoflurane	0.43 (0.22-0.85)		0.41 (0.18-0.96)	

GA = General anesthesia
*P-values based on chi-squared test
**P-values based on likelihood ratio test

Univariate and multivariate analysis of PACU fentanyl consumption

Six out of ten variables were identified as having a p-value ≤ 0.2 in univariate analysis, namely sex, inpatient or outpatient status, ASA classification, techniques of anesthesia, the induction agent and volatile agent. After being submitted to multivariate analysis, three variables remained statistically significant - sex, induction agent and volatile agent (Table 3). Girls were more likely to require fentanyl at the PACU compared to boys; the adjusted OR (95% CI) was 4.0 (1.04-15.48) (p=0.04). Compared to inducing anesthesia with propofol, induction with thiopental had a protective effect or a lower need for fentanyl at the PACU; the adjusted OR (95% CI) was 0.13 (0.02-0.65) (p=0.002). Induction with sevoflurane had a similar risk

of requiring PACU fentanyl as that following propofol induction; the adjusted OR (95% CI) was 0.77 (0.19-3.14). Maintenance anesthesia with isoflurane had a protective effect or a lower risk of requiring fentanyl at the PACU compared to sevoflurane; the adjusted OR (95% CI) was 0.41 (0.18-0.96) (p=0.04).

There was a positive association between PACU fentanyl consumption and oral analgesic drug requirement (paracetamol and/or ibuprofen) at the PACU; the OR (95% CI) was 4.75 (1.85-12.19) (p=0.0013). There was no association between intraoperative fentanyl consumption and PACU fentanyl consumption (p=0.9).

Perioperative adverse events

Of the 147 children, 58 children (39.5%) were given fentanyl ≤ 1 mcg/kg intraoperatively while 89 children (60.5%) received fentanyl > 1 mcg/kg. The major intraoperative adverse events included laryngospasm (3 children) and bradycardia (3 children); there were no other serious complications intraoperatively. At the PACU, the most common complication was nausea and vomiting (13 children). The serious PACU complication was reintubation (one child) which the child received fentanyl > 1 mcg/kg. Three children had shivering. Four out of 52 in surgical day-cases had unplanned admission. There were no differences in the incidence of intra-operative and PACU adverse events between the group receiving a fentanyl dosage ≤ 1 mcg/kg and the group receiving a dosage > 1 mcg/kg intra-operatively (Table 4). None of the complications were significantly correlated with intraoperative fentanyl consumption (p>0.05).

Table 4 Perioperative adverse events and intraoperative fentanyl consumption

Complication	Fen ≤ 1 mcg/kg n (%) (N=58)	Fen > 1 mcg/kg n (%) (N=89)	P*
Intraoperative			
Laryngospasm	1 (1.72)	2 (2.24)	0.71
Bradycardia	1 (1.72)	2 (2.24)	0.71
Hypotension	0	0	
PACU			
Nausea/vomiting	5 (8.62)	8 (9.0)	0.82
Shivering	1 (1.72)	2 (2.24)	0.71
Reintubation	0	1 (1.12)	0.82
Urinary retention	0	0	
Unplanned admission	1 (5.56)†	3 (8.82)‡	0.67

Fen = Fentanyl

*P-values based on chi-squared test or Fisher's exact test

†N=18, ‡N=34

Discussion

The authors conducted the study based on a retrospective review to find out if, in the authors' clinical practice, different techniques of anesthesia influence intraoperative fentanyl consumption in children and also to simultaneously examine other factors which could be associated with intraoperative and PACU fentanyl consumption using univariate and multivariate logistic-regression analysis to eliminate confounding factors in the independent variables. Previous studies have found that the anesthetic technique influenced postoperative pain scores in children.[9-11] However, no studies have examined whether different techniques of anesthesia or other predictive factors could be associated with perioperative opioid consumption in children.

Factors associated with intraoperative fentanyl consumption

The predictive factors of intraoperative fentanyl consumption (> 1 mcg/kg versus ≤ 1 mcg/kg) were the technique of anesthesia and the type of surgery. General anesthesia combined with a caudal or ilioinguinal nerve block had a protective effect in significantly lowering the amount of intraoperative fentanyl required compared to general anesthesia alone ($p<0.001$). These results confirmed that combining regional anesthesia with general anesthesia played a major role in perioperative pain management in pediatric patients, as also suggested by other studies.[5-7,9-11] Although a rare complication, such as sacral osteomyelitis, has been reported to occur during the use of a caudal block and an accidental puncture of the small bowel has also been reported during the use of a ilioinguinal nerve block which complications related regional anesthesia were not found in our study, the authors still considered these blocks to be safe and effective techniques in pediatric patients.[3,4] Based on this result, it was the most impact to our clinical practice to encourage our attending anesthesiologists to perform regional anesthesia combined with general anesthesia in pediatric urologic surgery. We also found that the more complex operations like orchidopexy and hypospadia repair required higher dose of intraoperative fentanyl consumption compared to the simpler operation (herniotomy) regardless of the duration of surgery ($p=0.013$). The children's age, sex, inpatient or outpatient status, ASA classification, duration of surgery and the type of anesthetic agent were not predictive of intraoperative fentanyl consumption.

Factors associated with PACU fentanyl consumption

In order to analyze the same period of postoperative fentanyl consumption throughout the study, we focused on PACU fentanyl consumption which represented only the first couple of hours of postoperative fentanyl consumption because more than one-third of the children were outpatients (35%). The predictive factors of postoperative fentanyl consumption (any fentanyl requirements versus no requirements) were sex, the type of an induction agent and the volatile anesthetic agent used. The children's ages, inpatient or outpatient status, ASA classification, duration of surgery, technique of anesthesia and intraoperative fentanyl consumption were not predictive of PACU fentanyl consumption.

Sex

Despite the fact that the number of girls was far less than that of boys (11% versus 89%), the PACU fentanyl higher requirement of girls was nevertheless significant (p=0.04). Recent pain studies[12,13] and review articles[14] in adults have shown that sex differences have an impact on pain sensitivity and pain perception. Paller et al.[13] reported that women were more pain sensitive, experienced greater clinical pain and suffered greater pain-related distress than men according to the gonadal hormone level in cycling women, which has a substantial impact on pain perception and the analgesic response. Yet little attention has been given to pediatric populations. Hechler et al.[15] reported that adolescent girls reported higher pain intensity than boys suffering from cancer pain. A study of Allen et al.[16] supported these results under laboratory pain tasks studies in children 8-18 years old finding that girls had more pain than boys, which they explained by the lower cortisol level associated with higher pain reactivity and decreased pain tolerance in girls compared to boys. To our knowledge, our study is the first to examine postoperative (PACU) fentanyl requirements in children under 9 years old, in which we found that girls needed more fentanyl than boys, which in assumed to be correlated with greater pain in girls. One study suggests that sex differences in pain responsivity in children under 10 years old might be explained by parent or maternal-child relationships and expectations that might contribute to sex-differentiated pain outcomes.[17]

Anesthetic agents

The induction agent, sodium thiopental, decreased the requirement for PACU's fentanyl compared to propofol (p=0.002). Earlier studies have found that, compared to propofol, sodium thiopental produces less pain during injections,[18-20] and has rapid induction[19] and longer duration of action. This faster induction might lead to the less experience of pain and provide more sedation synergistically with other anesthetic agents and, thus, lead to a lower fentanyl requirement at the PACU. Anesthesia induced with sevoflurane increased the requirement for PACU fentanyl similarly to propofol. Also, maintenance anesthesia with sevoflurane led to a greater dose of fentanyl when compared to isoflurane (p=0.04). We assume this could be explained by the fact that sevoflurane leads to a faster recovery from anesthesia compared to isoflurane[21,22] and it also has a higher incidence of emergence delirium than halothane,[23] isoflurane[24] and propofol.[25] Thus, patients treated with those agents which are associated with a faster recovery or development delirium tended to require greater use of fentanyl at the PACU, possibly due to misinterpretation of pain assessment which in turn might explain why sevoflurane increased the amount of PACU fentanyl consumption compared to isoflurane in the present setting. Therefore, sevoflurane induction and the maintenance of anesthesia were related with a greater dose of PACU fentanyl consumption in our children.

PACU fentanyl consumption was correlated with the oral analgesic (acetaminophen and/or ibuprofen) used in PACU. It is assumed that those children who had moderate to severe pain

needed both intravenous fentanyl and oral analgesic drugs at the PACU. Another interesting result showed no association between intraoperative and postoperative fentanyl consumption ($p>0.05$), which means the use of fentanyl intraoperatively did not have any impact on the use of fentanyl postoperatively. Finally, we could not find any correlation between intraoperative fentanyl consumption and intraoperative or postoperative complications, although this might be from small events of those complications.

Strengths and limitations

The main strength of the present study was the rigorous statistical analysis, with both univariate and multivariate logistic analysis appropriately performed to control potential confounding factors, leading to a high level of reliability to the finding of this study. There were a few limitations of the study. First, it was a retrospective study in which selection bias could not be fully controlled and in which some variables which might have been associated with postoperative fentanyl consumption were not obtained, for example pain scores at the PACU and ward, and the amount of intravenous fentanyl or oral analgesic required at the ward. Secondly, the PACU fentanyl consumption might not have represented the entire postoperative fentanyl consumption (64.6% were inpatients) because fentanyl required at the ward was not obtained so that sex differences or anesthetic agents might not be the real predictive factors of postoperative fentanyl consumption in admission patient. Finally, because of the small events of the perioperative complications in our patients, we could not detect any association between intraoperative fentanyl consumption and perioperative fentanyl-related complications, which, considering the very few complications in our patients, will likely require a very large sample size for adequate power to reveal the relationship between the two factors.

Conclusions

The different techniques of anesthesia and the type of surgery were predictive factors of intraoperative fentanyl consumption in pediatric urologic surgery which combined regional with general anesthesia in pediatric urologic surgery would be the routine clinical practice in our hospital. The predictive factors of PACU fentanyl consumption included female sex, propofol and sevoflurane as induction agents and sevoflurane as maintenance of anesthesia. No association was found between intraoperative fentanyl consumption and perioperative fentanyl complication.

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