PERIODICUM BIOLOGORUM
VOL. 115, No 2, 219–224, 2013

UDC 57:61
CODEN PDBIAD
ISSN 0031-5362

Original scientific paper

Femoral nerve block- or intravenous- guided patient control analgesiafor early physical rehabilitation after anterior cruciate ligament reconstruction in "fast-track" orthopedics: what is optimal?

DUBRAVKA BARTOLEK HAMP
EDUARD ROD
ANDREJ RADIĆ
DARJA GRANEC
MLADEN RAKIĆ

"St. Catherine" Orthopaedics,
Surgery, Neurology and Physical Medicine and Rehabilitation Specialty Hospital,
Zabok, Croatia

Correspondence:
Dubravka Bartolek Hamp, PhD, MD
"St. Catherine" Orthopaedics,
Surgery, Neurology and Physical Medicine and Rehabilitation
Specialty Hospital,
Bračak 8, Zabok, Croatia
E-mail: dubravka.bartolekhamp@inet.hr

Nonstandard abbreviations:

APS	acute pain service
CPNB	continuous block of peripher nerve
FB	femoral nerve block
IV	intravenous analgesia
LA	local anaesthetic
NSAID	non-steroid anti-inflammatory drug
PCA	patient control analgesia
PHR	physical rehabilitation
PNB	block of peripher nerve
RACL	anterior cruciate ligament reconstruction

Received May 15, 2013.

Abstract

Background and purpose: *"Fast-track" orthopaedics characterizes early start of physical rehabilitation (PHR). Quality of mobilization depends on pain therapy success and preservation of motor function and muscle strength. Patient-control-analgesia (PCA), as an upgrade of continuous intravenous (IV) or regional analgesia (FB) makes the modern base in treatment of acute pain. The aim of the study was to determine more effective post-operative PCA-analgesia (IV-PCA vs. FB-PCA) for early PHR in "fast-track" orthopaedics. Materials and Methods: Prospective, observer-blinded study included 40 adults (bought gender, ASA I/II) scheduled for anterior cruciate ligament reconstruction (RACL). Spinal anaesthesia (12.5 mg, 0.5% levobupivacaine; G27-Pencil-Point) was performed in all patients. Patients were divided in two equal groups. In Group IV-PCA intravenous (fentanyl 0.5-1μg $kg^{-1}h^{-1}$), and in Group FB-PCA regional (femoral block: 0.125% levobupivacaine, 8 ml h^{-1}) PCA-analgesia (Group IV-PCA: fentanil 10μg/8min/x6max; Group FB-PCA: 0.125% levobupivacaine, 8ml/30min/x3max) was established after surgery. Pain score (VAS) was assessed during 24-hours and accepted as satisfactory by ≤3. Diclofenac 75 i.v. was given in two doses, immediatelly and 12 hours after surgery. Paracetamol 1g was added intravenously if VAS was ≥ 4. Start of early PHR was planned six hours after surgery. Result: FB- and IV-PCA provided equally effective analgesia during first 24-hours after RACL (VAS≤3). Early PHR was possible 6-hours after surgery in 85% of Group FB-PCA (Group IV-PCA=20%) (P=0,0001) due to significantly lower VAS 0,7+/–0,2 (Group IV-PCA=3,0+/–0,2)(P<0,0001). Residual motor block, presented in three patient (15%) with FB-PCA, disabled the onset of PHR. Additional analgesic dose was more need in Group IV-PCA (40%) (Group FB-PCA=10%) (P<0,0001). Conclusion: FB-PCA allows more successful pain-free early PHR for orthopaedics "fast-track" ACL reconstruction compare to IV-PCA, excluding 15% of the FB-PCA patients in whom residual muscle weakness was present.*

INTRODUCTION

"Fast-track" orthopaedic surgery integrates surgical, anaesthesia and rehabilitation methods in unique protocol to achieve patient rapid recovery, early mobilisation and fast hospital discharge (*1, 2*). Minimally

invasive surgical techniques, adjusted program of physical rehabilitation (PHR) and structured approach to the acute pain treatment build the base of "fast-track" orthopaedics (*3, 4*).

Anterior cruciate ligament (ACL) reconstruction is elective, outpatient procedure where postoperatively pain intensity (Visual Analogue Score; VAS 4-7) requires complex multimodal analgesia approach. Curatolo M (5) suggest two current concepts of analgesics combination for "fast-track" ACL reconstruction: 1) intravenous opioid (morphine) and NSAID or acetaminophen, and 2) regional analgesia technique (neuroaxial or peripheral nerve block) supplemented by NSAID or acetaminophen intravenously (A: level of evidence). Combination of NSAID and tramadol (or dextromethorphan) indicated reduced analgesia benefit (C: level of evidence). Ideally, multiple non-opioids drugs (COX-2 inhibitors and gabapentin), could be combined to achieve optimal opioid-free pain relief (A: level of evidence)(*5*). Some authors combine these drugs with intra-articular local anaesthetic infiltration (20 ml of 0.5% bupivacaine with 10 mg of morphine (Level I of evidence)(*6*) after tourniquet releasing (*7*) or preoperatively (8 ml of 0.5% bupivacaine and 0.1 mg of fentanil)(*8, 9*).Intra-articular knee analgesia is simple and outstanding of performance (10) but its application is avoided because of adverse effects of local anaesthetics (bupivacaine, lidocaine) on the cartilage of the knee joint (*11*).

Both proposed analgesia methods include pro- at contra- facts. Intravenous opioid analgesia improves success postoperative pain relief with good condition for early PHR but with high incidence of dose-related side effects (nausea, vomiting, urinary retention, sedation, hypoventilation, ileus) and consequently developed acute opioid tolerance and hyperalgesia (*12*). Peripheral nerve blocks (PNB) analgesia improves better pain control, reduce opioid-related side effects and enable safer "fast-track" recovery process compare to intravenous analgesics (*13, 14*). On other side, PNB may be accompanied by muscle weakness, due to consequent motor blockade of peripheral nerve what disables the start of PHR (*15*).

What can improve the bought analgesia options for "fast-track" ACL reconstruction? Following the recent protocols (*16*), multimodal ("balanced") and patient control (PCA) analgesia make the gold standard of "fast-track" surgery. In multimodal analgesia, more than one analgesics or technique with additive or synergistic analgesics effects are used to reduce analgesics-related side effects) (*17*). Intravenous or perineural PCA analgesia contribute to the overall reduction of consumed doses of analgesics to the individual needs of patients and bought technique may better optimize patient conditions for PHR.

The aim of this study was to assess the optimal multimodal analgesia approach afterRACL "fast-track" surgery for early PHR: intravenous opioid- vs. femoral nerve block- guided patient control analgesia (PCA).

MATERIALS AND METHODS

Prospective, observer-blinded study started after approval of Ethics Committee. The studyincluded 40 adults (32–51 age; bought gender; ASA I/II) scheduled for elective RLCA surgery in spinal anaesthesia (12.5 mg, 0.5% levobupivacaine; G27-Pencil-Point). Premedication (midazolam 20 $\mu g\ kg^{-1}$ intravenously) was applied 15 min before initiation of anaesthesia procedure.

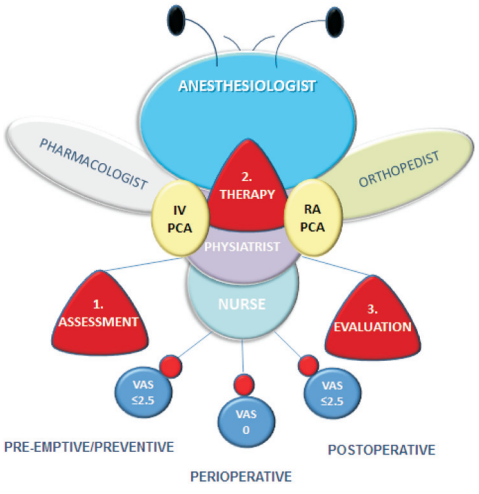
Patients were divided in two equal groups. In Group IV-PCA basal infusion of intravenous opioid (fentanil 0.5–1 $\mu g\ kg^{-1}\ h^{-1}$) was started immediately after surgery. In Group FB-PCA basal infusion of perineural local anaesthetic (femoral nerve: 0.125% levobupivacaine, 8 ml h^{-1}) was applied in addition to single-shot analgesia (sciatic nerve: 0.125% levibupivacaine, 20 ml). PCA--analgesia was established in bought study groups after surgery. Settings for PCA mode were: in Group IV-PCA 10 μg of fentanil on demand, with lock-out of 8 min and 6 requests maximal in one hour, and in Group FB-PCA 8 ml of 0.125% levobupivacaine on demand, with lock-out of 30 min and 3 requests maximal in one hour.

Pre-emptive/preventive analgesia (paracetamol 1g i.v.) was applied 30 min before start of surgery if VAS score was >3.

Additional intravenous analgesia was provided by diclofenac (75 mg, immediately and 12 hours after surgery) independently from VAS score, and paracetamol (1g up to four times in 24 hours) if VAS was =4.

Multidisciplinary acute pain servis (anaesthesiologist, physiatrist, and surgeon) supervised analgesic therapy, pain intensity and optimal time for the start of physical rehabilitation independently from study design and protocol (Schema 1). Pain was assessed by visual analogue pain scale (VAS) before and during 24 hours after surgery. VAS ≤3 was accepted as satisfactory analgesia.

Physical rehabilitation was conducted in two phases: Phase A=immediately-static methods ("The GameReady" to providing cold and knee compression, reducing pain



Scheme 1: *Multi-disciplinary Acute pain Service (APS)*

TABLE 1

Procedural characteristics of the study groups

		Group IV-PCA i.v. fentanil (1μg kg^{-1} h^{-1}) PCA (10 μg/ 8 min/ x 6 max) (N=20)	Group FB-PCA regional 0.125% levobupivacaine (10 ml h^{-1}) PCA (8 ml/ 30 min/ x 3 max) (N=20)	P value
Demographic date	Age (years)	42±9	36±3	0,0742
	Gender (F:M)	0,45	0,5	0,6697
	ASA (II:I)	0,32	0,4	0,6122
	BMI (kg/m^2)	23±0.7	21±2	0,1050
	Hight (m)	1,75±7	1,78±2	0,9854
	Weight (kg)	73±6	68±10	0,0627
Duration of suergery	(hours)	2,5±0,9	2,1±0,7	0,1221
Spinal anasthesia duration		3,8±0,5	4,2±1,0	0,1179

and swelling, and "Kinetek"- allows passive joint stretching by previously entered parameters which adjusts the degree of movement) and Phase B=6 hours after surgery--dynamic methods (getting up, walking on crutches, individually tailored relieving exercises).Static methods of PHR have been applied in all patients in bought study groups. Dynamic methods of PHR were introduced after individual clinical assessment of patients and under stabile vital condition by VAS ≤3. PHR did not start if total absence of pain (VAS 0) was assessed. It was began when correction in analgesia therapy lead to increase the patient pain sensation to at least of its minimum value (VAS 1).

PCA was discontinued eight hours before patient discharge in bought study groups. At this time, diclofenac second dose was already added. Paracetamol 1 g intravenously was applied only if VAS increasesabove 3.

Date was analysed by "Interactive Statistical Calculation Pages" software; htpp://statpages.org.

RESULTS

Study groups were comparable to demographic data. Average age of patients ranged between 33–51 years. Gender (F:M)(0.45-0.5) and ASA risk (II:I)(0.32–0.4) ratio was equally represented in- and between- study groups. Mean body mass index (BMI) was under normal weight range (21–23 kg m^{-2}) in all patients (Table 1).

Duration of ACL reconstruction was almost the same in two groups (Group IV-PCA 2.5 vs. Group FB-PCA 2.1 hours)(P=0.1221). Recovery after spinal anaesthesia, including sensor and motor function, appears after 3.8 (Group IV-PCA) and 4.2 hours (Group FB-PCA) and did not differ among study groups (P=0.1179).

Femoral nerve block- and intravenous-PCA analgesia provided effective analgesia during first 24-hours after ACL reconstruction (VAS≤3). Significantly lower mean VAS was detected in FB-RCA (0,7+/–0,2 vs. 3,0+/–0,2 in Group IV-PCA)(P<0,0001)(Figure 1).

The maximal daily VAS scores were detected 8 hours after surgery (and 2-hours after PHR) in bought groups and was significant lower in Group FB-PCA (1.5+/–0.5 vs. 4.1+/–7 in Group IV-PCA)(P=0.0001).

Early PHR was possible 6-hours after surgery in 85% of Group FB-PBA (Group IV-PCA=20%) (P=0,0001) (Figure 2).

Additional analgesic dose was more needed in Group IV-PCA (40%) (Group FB-PCA=10%) (P<0,0001) (Table 2). Difference between planed and consumed daily dose of analgesics was less in IV-PCA Group (44%, vs. 86% in Group FB-PCA)(P=0.0001).

Pre-emptive/preventive i.v. or regional analgesia had success in pain reduce before surgery but, followed by

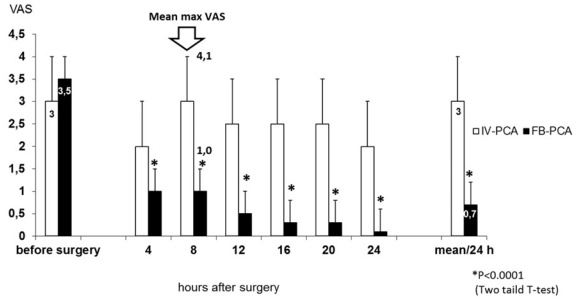


Figure 1. *Post-operative acute pain score (VAS) during intravenous (IV-PCA) and femoral nerve block (FB-PCA) analgesia*

TABLE 2

Characteristics of analgesia

		Group IV-PCA	Group FB-PCA	P value
Pre-emptive		8 (40%)	9 (45%)	0,3571
Additional		8 (40%)	**2 (10%)**	**0,0001***
PCA duration (hours)		16±2	15±2	0,1221
Consuption (mg/24 hours)	Maximal planed	3,6	174	
	Mean request for demand dose	14	2	
	Continuous dose	1,1	130	
	Total consumed dose	1,6	130	
	Δ planed/consumed (%)	44	**86**	**0,0001***

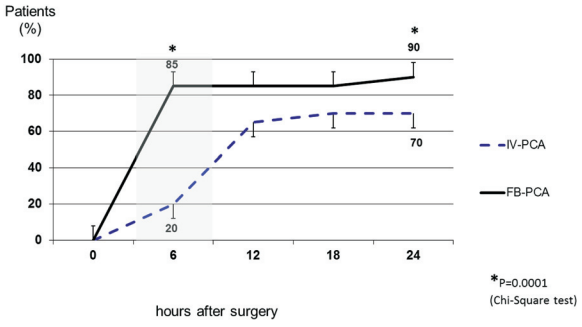


Figure 2. *Start of early physical rehabilitation with fentanil (IV-PCA) and perineural femoral block FB-PCA analgesia after ACL reconstruction*

spinal anaesthesia, did not approve its efficiency after surgery neither in Group IV-PCA or FB-PCA.

Slight adverse effects were more frequently presented during IV-PCA but only in first 6-hours after surgery (80%) to compare FB-PCA analgesia (15%) (Table 3) (Figure 3).

In the study groups, no serious complication was observed, related to analgesic's therapy. Residual motor

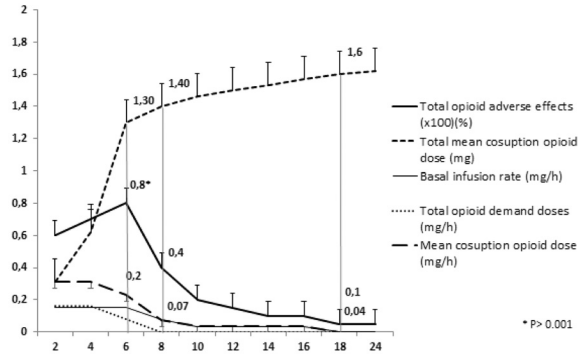


Figure 3. *Frequency of fentanil adverse effects durning IV-PCA analgesia in correlation with mean consuption dose (mgh^{-1})*

block, presented in three patients (15%) with FB-PCA, disabled the onset of early PHR on the surgical day. In opioid PCA treated patient, dynamic physical rehabilitation started successful in mostly patients at the first postoperative day (24 hours after ACL procedure).

DISCUSSION

Efficient acute pain treatment after RACL surgery is possible with structured and uniform protocols of anaesthesia and analgesia guided by the hospital Acute Pain Service (APS) where continuous assessment of pain is present (*18*). Perineural or intravenous patient control analgesia (PCA)(*19*), followed by quality pain assessment and therapy adaptation is integral part of current acute pain management.

Quality physical rehabilitation after "fast-track" ACL reconstruction depends on pain relive success, presence of analgesics adverse effects and stabile vital condition of patient (*20*). More than 40% of these patients experience moderate (VAS 4-6) to severe (VAS 7-8) pain in first hours postoperatively what inhibits the patient's desire to move and justified to use strong analgesics. On the other side, the presence of muscle weakness due to continuous peripheral motor nerve block (CPNB) analgesia prevents patients actively, rising and delay their recovery and rehabilitation.

In meta-analysis of randomized clinical trials, CPNB provides superior postoperative analgesia (maximal VAS= 2.8–3.8) compare to continuous use of opioid (5.4-6.4) in first 24 hours (*21*). We supposed that maximal 24-hours VAS was lower in our bought study groups (FB-PCA=1.0, IV-PCA=4.1) due to preoperatively application of sciatic nerve block in single-shot mode in FB-PBA group and use opioid fentanil instead morphine in IV-PCA group. Side effects compared to opioid analgesia reported by Richman JM were less with CPNB than opioid analgesia (POVN 21 vs. 49%, sedation 27% vs. 52%, pruritus 9.7 vs. 27%) (21). In the same meta-analysis, motor weakness was reported in 31% of 70 patients where continuous PNB analgesia was used. Although, its frequency was only 15% in our FB-PCA group of 20 patients, the data from meta-

TABLE 3

Adverse effects during intravenous-opioid and perineural-femoral patient guided analgesia

ADVERSE EFFECTS DURING ANALGESIA (6 hours after surgery)	Group IV-PCA N (%)	Group FB-PCA N (%)	P value
PONV	3 (15%)	0 (0%)	
Sedation (Ramsay sedation score > 3)	1 (5%)	0 (0%)	
Dizziness	2 (10%)	0 (0%)	
Weakness	7 (35%) (general)	3 (15%) (local)	
Hypotension	3 (15%)	0 (0%)	
Respiratory depresion	0 (0%)	0 (0%)	
Total	**16 (80%)**	**3 (15%)**	**0,001**

-analysis is more objective considering the total number of patients included in the study at this moment.

Total consumption of local anaesthetic dose is significantly lower after FB-PCA analgesia than continuous infusion mode whit identical analgesic effect. This allows-faster motor recovery and prevention of muscle wackiness after discontinuation of analgesia (*22*). Our total consumption dose of levibupivacaine in FB-PCA after RACL was 150 mg in 24 hours what was comparable with Contreras-Domínguez VA data (170 mg bupivacaine in 24 hours) (*22*). Success pain relief, minimal adverse effects, fast motor recovery and lower incidence of adverse effects associated with FB-PCA analgesia make it the method of choice in "fast-track" ACL reconstruction (*23*).

Capdevilla X reported that 11% of patients, despite the use of CPNB noted the wound pain 24–48 hours postoperatively and 17–22% of them required opioid analgesic 7 days after surgery (*13*). In our study we used fentanil rather than morphine because of its high lipid solubility that resulting in rapid onset of analgesia, lower-incidence of side effects and low risk of delayed respiratory depression (*24, 25*). Reasons for activity limitation in our IV-PCA analgesia were primary due to presence of mild opioids adverse effects (PONV 15%, feeling faint (35%) and dizziness 10%). These results were comparable with results of Capdevilla X who used morphine-PCA analgesia after ACL reconstruction (*13*). In our IV-PCA group adverse effects was presented significantly only during first six hours form the start of therapy. These data was in correlation with frequently need for fentanil demand doses during first two hours retrospectively. After reaching the optimal analgesic doses, requests for demand doses decreased and consequently theirs concomitant effects. Total opioid consumption significantly decreased in the remaining of 24 hours.

Maximal pain experience in our IV-PCA group was higher from the range designate to start of PHR start (VAS 4 vs. =3) during the opioid utilisation interval and this was the second reason for postponing the early PHR.

In bought study group IV- and FB-PCA analgesia was combined with non-opioid drugs (diklofenac and paracetamol) that decreased dose and minimized opioid and local anaesthetic side effects of primary therapy.

CONCLUSION

Multimodal analgesia in combination with femoral nerve bock-PCA analgesia represents a key of current and successful "fast-track"ACL reconstruction by minimizing postoperative pain, opioid-related organ dysfunction and facilitating the recovery process from anaesthesia.

REFERENCES

1. KEHLET H, WILMORE DW 2002 Multimodal strategies to improve surgical outcome. *Am J Surg 183:* 630–41.
2. MARCH L, WOOLF AD 2010 The global burden of musculoskeletal conditions – why is it important? Best Pract Res Clin Rheumatol 24 (6): 721.
3. LARSEN K, HANSEN TB, SØBALLE K, KEHLET H 2012 Patient-reported outcome after fast-track knee arthroplasty. Knee Surg Sports *Traumatol Arthrosc20(6):* 1128–35.
4. KEHLET H, DAHL JB 2003 Anesthesia, surgery and challenges in postoperative recovery. *Lancet 362:* 1921–8.
5. CURATOLO M, SVETICIC G 2002Drug combinations in pain treatment: a review of the published evidence and a method for finding the optimal combination. *Best Pract Res Clin Anaesthesiol 16(4):* 507–19.
6. HOSSEINI H, ABRISHAM SM, JOMEH H, KERMANI-ALG-HORAISHI M, GHAHRAMANI R, MOZAYAN MR 2012The comparison of intraarticular morphine-bupivacaine and tramadol--bupivacaine in postoperative analgesia after arthroscopic anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc 20(9):* 1839–44.
7. GULER G, KARAOGLU S, AKIN A, DOGRU K, DEMIR L, MADENOGLU H, BOYACI A 2004 When to inject analgesic agents intra-articularly in anterior cruciate ligament reconstruction: before or after tourniquet releasing. Arthroscopy20(9): 918–21.
8. MAYR HO, ENTHOLZNER E, HUBE R, HEIN W, WEIG TG 2007Pre- versus postoperative intraarticular application of local anesthetics and opioids versus femoral nerve block in anterior cruciate ligament repair. Arch Orthop Trauma Surg 127(4): 241–4.
9. NOYES FR, FLECKENSTEIN CM, BARBER-WESTIN SD 2012 The development of postoperative knee chondrolysis after intra-articular pain pump infusion of an anesthetic medication: a series of twenty-one cases. J Bone Joint Surg Am 15;94(16):1448–57.
10. ERDEN IA, ALTINEL S, SARICAOGLU F, ZEYBEK ND, AKINCI SB, ASAN E, AYPAR U 2012 Effect of intra-articular injection of levobupivacaine on articular cartilage and synovium in rats. Anaesthesist61(5):420–3.

11. NOYES FR, FLECKENSTEIN CM, BARBER-WESTIN SD2012 The development of postoperative knee chondrolysis after intra-articular pain pump infusion of an anesthetic medication: a series of twenty-one cases. J Bone Joint Surg Am 15;94(16):1448–57.
12. GUIGNARD B, BOSSARD AE, COSTE C, SESSLER DI, LEBRAULT C, ALFONSI P, FLETCHER D, CHAUVIN M2000 Acute opioid tolerance: intraoperative remifentanil increases postoperative pain and morphine requirement. Anesthesiology93(2): 409–17.
13. CAPDEVILLA X, DADURE C, BRINGUIER S, BERNARD N, BIBOULET P, GAERTNER E, MACAIRE P 2006 Effect of patient-controlled perineural analgesia on rehabilitation and pain after ambulatory orthopaedic surgery: a multicenter randomized trial. Anesthesiology 105: 566–73.
14. RICHMAN JM, LIU SS, COURPAS G, WONG R, ROWLINGSON AJ, MCGREADY J, COHEN SR, WU CL 2006 Does continuous peripheral nerve block provide superior pain control to opioids? A meta-analysis. Anesth Analg 102: 248–57.
15. HAMIDREZA ARTI1 AND SEYED ABDOULHOSSEIN MEHDINASAB 2011 The comparison effects of intra-articular injection of different opioids on postoperative pain relieve after arthroscopic anterior cruciate ligament reconstruction: A randomized clinical trial study. J Res Med Sci16(9): 1176–1182.
16. WHITE PF, KEHLET H, NEAL JM, SCHRICKER T, CARR DB, CARLI F 2007 Fast-Track Surgery Study Group. The role of the anesthesiologist in fast-track surgery: from multimodal analgesia to perioperative medical care. Anesth Analg 104(6): 1380–1396.
17. ELVIR-LAZO OL, WHITE PF 2011 The role of multimodal analgesia in pain management after ambulatory surgery. Curr Opin Anaesthesiol23(6): 697–703.
18. RAWAL N, ALLVIN R 1998 Acute pain services in Europe: a 17-nation survey of 105 hospitals. The EuroPain Acute PainWorking Party. Eur J Anaesthesiol 15: 354–63.
19. WERAWATGANON T, CHARULUXANUN S 2005 Patient controlled intravenous opioid analgesia versus continuous epidural analgesia for pain after intra-abdominal surgery. Cochrane Database Syst Rev 1:CD004088.
20. KEHLET H, WILMORE DW 2008 Review Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg 248(2): 189–98.
21. RICHMAN JM, LIU SS, COURPAS G, WONG R, ROWLINGSON AJ, MCGREADY J, COHEN SR, WU CL 2006 Does continuous peripheral nerve block provide superior pain control to opioids? A meta-analysis. Anesth Analg 102(1): 248–57.
22. CONTRERAS-DOMÍNGUEZ VA, CARBONELL-BELLOLIO PE, OJEDA-GRECIET AC, SANZANA ES 2007 Patient controlled analgesia reduces the consumption of bupivacaine in femoral nerve block for the treatment of postoperative pain after reconstruction of anterior cruciate ligament of the knee. Rev Bras Anestesiol 57(4): 356–65.
23. DOUGLAS A, LOGERSTEDT D, HUNTER-GIORDANO A, AXE MJ, SNYDER-MACKLER L 2012 Current Concepts for Anterior Cruciate Ligament Reconstruction: A Criterion–Based Rehabilitation Progression. J Orthop Sports Phys Ther 42(7): 601–614.
24. ROUSSIER M, MAHUL P, PASCAL J 2006 Patient-controlled cervical epidural fentanyl compared with patient-controlled iv fentanyl for pain after pharyngolaryngeal surgery. Br J Anaesth 96: 492–6.
25. BEILIN B, HOOFIEN D, PORAN R 2008 Comparison of two patient-controlled analgesia techniques on neuropsychological functioning in the immediate postoperative period. J Clin Exp Neuropsychol 30: 674–82.