ORIGINAL ARTICLE

Comparison of 2-Chloroprocaine, Bupivacaine, and Lidocaine for Spinal Anesthesia in Patients Undergoing Knee Arthroscopy in an Outpatient Setting

A Double-Blind Randomized Controlled Trial

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Background and Objectives: Knee arthroscopy is a well-established procedure in day-case surgery, which is frequently performed under spinal anesthesia. It is, however, controversial whether the choice for a specific local anesthetic translates into relevant outcomes. We hypothesized that the use of 2-chloroprocaine would be associated with a faster recovery from sensorimotor block.

Methods: Ninety-nine patients were included in this prospective, double-blind, randomized controlled trial and randomly allocated to receive either 40 mg 2-chloroprocaine, 40 mg lidocaine, or 7.5 mg bupivacaine. The primary endpoint was the time until complete recovery of sensory block. Secondary endpoints included time to recovery from motor block, failure rates, incidence of hypotension/bradycardia, postoperative pain, first mobilization, voiding and discharge times, and the incidence of transient neurologic symptoms. This clinical trial was registered prior to patient enrollment (EudraCT 2011-003675-11).

Results: Patients in the chloroprocaine group had a significantly shorter time until recovery from sensory block (median, 2.6 hours; interquartile range [IQR], 2.2–2.9 hours) than patients in the lidocaine group (3.1 hours; IQR, 2.7–3.6 hours; $P < 0.006$) and in the bupivacaine group (6.1 hours; IQR, 5.5 hours to undefined hours; $P < 0.0001$). Chloroprocaine was associated with a significantly faster recovery from motor block than lidocaine and bupivacaine. Times to first mobilization, voiding, and discharge were significantly shorter for chloroprocaine when compared with bupivacaine, but not with lidocaine. In the bupivacaine group, patients needed significantly less rescue medication for postoperative pain when compared with lidocaine and chloroprocaine. Groups did not differ with respect to patient satisfaction, incidence of bradycardia/hypotension, and transient neurologic symptom rate.

Conclusions: For spinal anesthesia in patients undergoing ambulatory knee arthroscopy, chloroprocaine has the shortest time to complete recovery of sensory and motor block compared with bupivacaine and lidocaine.

(*Reg Anesth Pain Med* 2016;41: 576–583)

In day-case surgery, knee arthroscopy is frequently performed under spinal anesthesia.[1–3] The short duration of the procedure and the high turnover in a day-case center necessitate the performance of neuraxial anesthesia with local anesthetics that exhibit fast onset and quick recovery kinetics.[4]

Lidocaine has an attractive pharmacokinetic profile as it shows a rapid onset and allows a fast recovery of both motor and sensory block (130–170 minutes).[5] However, when compared with other local anesthetics, the use of lidocaine for spinal anesthesia is associated with an increased risk of transient neurological symptoms (TNS) including back and leg pain.[6–8]

Also bupivacaine has been widely studied for surgical procedures in the lower extremities.[9] Bupivacaine may provide prolonged postoperative analgesia and has a lower incidence of TNS. However, the longer duration of action (240–380 minutes) may delay the recovery of motor function, cause urinary retention, and therefore ultimately may lead to a delayed discharge from the hospital.[9]

Over the last few years, 2-chloroprocaine has regained popularity. While 2-chloroprocaine was withdrawn from the market in the 1980s because of concerns about neurotoxicity,[10,11] a new formulation without preservatives that has no longer been associated with neurotoxicity[12,13] was introduced into clinical routine in 2004. 2-Chloroprocaine is characterized by both a very fast onset (5–10 minutes) and a quick recovery time (70–150 minutes).[14,15]

It has not been systematically studied whether the differences in pharmacokinetics of the 3 local anesthetics can translate into an improvement of relevant outcomes after spinal anesthesia in day-case surgery. We hypothesized that in patients undergoing knee arthroscopy the use of 2-chloroprocaine would be associated with a decrease in the time until recovery from sensorimotor block that would translate into a reduction of ambulation and discharge times. To test this hypothesis, we compared 2-chloroprocaine with equivalent doses of not only lidocaine, but also with bupivacaine, which is still considered by several authors as criterion standard for spinal anesthesia.[9]

METHODS

Study Design and Population

This prospective, double-blind, randomized controlled clinical trial included 99 patients scheduled for diagnostic knee arthroscopy in an ambulatory setting. The study protocol was approved by the research ethics committee of the University Hospitals of the KU Leuven (EC S53487, September 21, 2011) and the Belgian Government, and it was registered in the EUDRACT (2011-003675-11). Patients were enrolled between April 2013 and May 2014.

We included patients 18 years or older who were scheduled for elective knee arthroscopy under spinal anesthesia and having an ASA (American Society of Anesthesiologists) physical status I to III. Exclusion criteria were patients using antidepressant drugs

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Accepted for publication March 27, 2016.

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This clinical trial was partially sponsored by a research grant from the European Society of Regional Anaesthesia and Pain Therapy (ESRA).

Parts of this study were presented as an abstract on the 34th Annual ESRA Congress in Ljubljana, Slovenia, September 3, 2015.

The authors declare no conflict of interest.

Clinical Trial Registry: EudraCT 2011-003675-11.

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ISSN: 1098-7339

DOI: 10.1097/AAP.0000000000000420

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and/or antipsychotic medication, allergies to local anesthetics, and known prostate hypertrophy (because of the increased risk of urinary retention).

After obtainment of written informed consent, patients were randomly allocated to receive intrathecal anesthesia with either 2-chloroprocaine, lidocaine, or bupivacaine using a computer-generated random table (GraphPad Software Inc, La Jolla, California). Allocation concealment was ensured by enclosing assignments in sealed, opaque, sequentially numbered envelopes, which were opened only after arrival of the patient in the operating room.

Study Intervention

Patients in the chloroprocaine group were given 40 mg of 1% preservative free plain 2-chloroprocaine[16–18] intrathecally; patients in the lidocaine group received 40 mg of 1% plain lidocaine,[19,20] whereas patients in the bupivacaine group received 7.5 mg of 0.5 % plain bupivacaine as intrathecal anesthetic.[9,21] All dosages were diluted with saline to a total volume of 4.5 mL in an unlabelled syringe.

The study medication was prepared by a consultant staff member of the Department of Anesthesiology who was not further involved in the perioperative care of the respective patients or in data gathering and study visits.

Anesthetic and Perioperative Management

The anesthetic technique was standardized for all patients. Before the placement of the intravenous catheter, patients were orally premedicated with 0.5 mg alprazolam and received an intravenous fluid bolus of 200 mL balanced crystalloid infusion.

The spinal puncture was performed in the sitting position with a 27-gauge, 103-mm Whitacre needle at the L3-L4 or L4-L5 interspace. The patient was turned supine, and surgery was started once a T10 sensory block had been reached.

Block failure was defined when the rostral spread of the sensory block had not reached the T12 level after 15 minutes. In these cases, patients were converted to general anesthesia using an induction dose of 2 mg/kg propofol and 0.2 μg/kg sufentanil.

In case of an insufficient sensory block during the procedure (defined as a sensory block reaching higher than T12, but presence of pain intraoperatively), patients received 2.5 to 5 μg of sufentanil, which was repeated after 5 minutes if necessary up to a maximum dose of 10 μg. If pain still persisted, general anesthesia with propofol 2 mg/kg was induced, and supplementary sufentanil was given as deemed necessary by the attending anesthesiologist.

Clinically relevant hypotension (defined as a decrease in systolic blood pressure >30% from baseline values) was treated with 5 mg ephedrine, which was repeated after 10 minutes if the hypotension was still present, and bradycardia (defined as a heart rate <45 beats/min) was treated with atropine 0.5 mg.

Intraoperatively all patients received 2 g of paracetamol and 30 mg of ketorolac intravenously (IV), except in case of any contraindication, for postoperative pain control.

Postoperative rescue pain medication was administered according to our institutional standards for postoperative analgesia. The patients received 0.03 mg/kg piritramide IV (maximum of 8 mg) if the VAS (visual analog scale) score for pain was greater than 30, and if pain scores remained high (>30 VAS), a bolus of 3 mg/kg tramadol in combination with 100 mg of alizapride was given. Paracetamol 1 g was repeated 6 hours after the first dose if necessary.

Postoperative nausea and vomiting was treated with ondansetron 4 mg IV.

Study Outcomes

The primary outcome of the study was the time until complete recovery of the sensory block (defined as the return of cold sensation down to the level of S5). Secondary outcomes included the time until recovery of the motor block (defined as reaching Bromage scale = 0), voiding times, ambulation times (defined as time until the first mobilization), discharge times, the incidence of hypotension/bradycardia (defined as above), rate of conversion to general anesthesia, need for and doses of supplementary analgesics administered intraoperatively and postoperatively, and the incidence of TNS. Transient neurological symptoms were defined as lower back pain radiating from the gluteal region to the lower extremities.[6] The study was to be stopped if the TNS incidence was significantly higher than 5% (using a 1-sided 5% Lan-DeMets stopping boundary for continuous safety monitoring) in all groups combined or in 1 of the 3 groups separately.

Data Collection

The level of sensory and motor block was noted 5, 10, and 15 minutes after injection of the local anesthetic, by testing for the loss of cold sensation downward the midclavicular line, starting at T2, using the arm with the unblocked C5-C6 dermatomes as reference point.

The onset of motor block was tested using the modified Bromage scale (0 = no block; 1 = impaired movement at the hip, but normal knee and ankle movement; 2 = impaired movement at hip and knee but normal ankle movements; 3 = impaired movement at hip, knee, and ankle).

Hemodynamic parameters were recorded every 5 minutes until the end of surgery, every 15 minutes during the first postoperative hour, and then every hour until discharge.

The incidence of failed spinal anesthesia, conversion to general anesthesia, the need for additional intraoperative analgesia, and postoperative rescue pain medication were documented.

After end of surgery, regression of motor and sensory block was assessed every 15 minutes using the modified Bromage scale and testing the loss of cold sensation. Time to complete recovery of sensory block (defined as recovery of sensation at S5), motor block, and time until first mobilization (ambulation time) were recorded. Time until first voiding was noted, and if urinary retention was suspected, a bladder scan was taken. When the measured volume was 500 mL or more, a single urethral catheterization was performed.

Patient overall satisfaction was measured using a visual numeric rating scale reaching from 0 to 10 (0 = not satisfied at all; 10 = extremely satisfied).

All patients were conscientiously questioned about various signs of TNS: back pain, leg pain, and irradiating pain from the buttocks to the lower extremities. The incidence of TNS was recorded at discharge and 24 hours postoperatively (by contacting the patient via phone). They were advised to contact us if they had any symptoms after 24 hours. In case of TNS, the patient was contacted daily until the problem was resolved.

All data were collected by the study nurse of the department who was blinded to the treatment.

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Statistical Analysis

Sample Size Calculation

The sample size calculation was performed with SAS, version 9.2 of the SAS system for Windows (SAS Institute Inc, Cary, North Carolina).

This size was calculated to detect a difference in complete recovery of sensory block between the groups and was based on (3) pairwise 2-sided Mann-Whitney *U* tests. With a Bonferroni correction and an overall type I level of 5%, we used an α level of 1.667% per pairwise comparison. The exact times until complete recovery of sensory block for the different local anesthetics are not known from the literature. Instead, we based our sample size estimation on estimates for the ambulation time that were obtained from the literature: mean of 191 (SD, 30) minutes, 134 (SD, 14) minutes, and 114 (SD, 14) minutes for bupivacaine, lidocaine, and chloroprocaine, respectively.[16,20,21] Using a conversion formula, a lognormal distribution for the time until complete block recovery was assumed for each group. With 25 subjects in each group, the power is at least 98% for each pairwise comparison to detect differences as large as described in literature. The study has only been powered for the primary endpoint, which is the time until complete recovery of sensory block.

After inclusion of 75 patients (25 per group), it was observed that 6 patients had to be converted to general anesthesia and that in total 23 (bupivacaine: 18, lidocaine: 4, chloroprocaine: 1) of the 69 remaining patients had been unintentionally discharged without a complete recovery of the sensory block (resulting in censored data). Therefore, we decided to perform an additional recruitment to compensate for the decrease in power (due to conversions and the presence of censoring). The planned analysis was changed from pairwise Mann-Whitney *U* tests into Wilcoxon tests for censored data. The test is also referred to as the Gehan test or the Breslow test (and is obtained by specifying the option "test = Wilcoxon" in the strata statement of the SAS procedure PROC LIFETEST). Using a simulation study, it was shown that with the recruitment of at least 5 additional patients per group the original level of power was protected. Notably, this decision was made in a blinded fashion; that is, no comparison of ambulation times had been performed prior to this recalculation of the required sample size. The recruitment of additional patients was approved by the research ethics committee of the University Hospitals of the KU Leuven (EC S53487, January 20, 2014).

Data Analysis

The times until complete recovery of motor and sensory block were compared between groups using Wilcoxon tests for censored data. Patients without complete recovery at discharge were censored. Times were measured from the moment of spinal injection. Using a Bonferroni correction with $\alpha = 5\%$, a *P* value was considered significant if smaller than 0.01667. The complement of Kaplan-Meier estimates was used to construct the cumulative distribution of the time until complete recovery of sensory and motor block. The same methodology was used for the voiding times, censoring patients who required a bladder catheter.

Kruskal-Wallis and Fisher-Freeman-Halton tests were used to compare ambulation times, discharge times, intraoperative

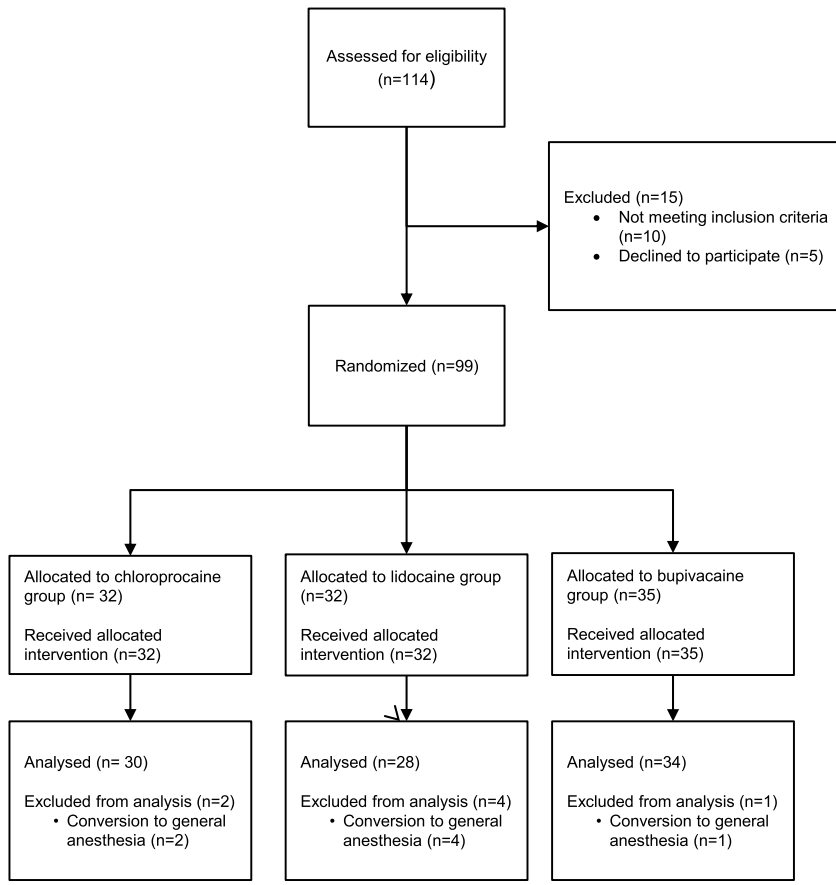

FIGURE 1. Study flowchart.

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TABLE 1. Demographic and Biometric Data

	Chloroprocaine	Bupivacaine	Lidocaine
	n = 32	n = 35	n = 32
Age, median (min-max), y	47.5 (21–76)	49 (20–66)	48 (19–72)
Weight, median (min-max), kg	77.5 (52–115)	74 (49–110)	77 (62–105)
Height, median (min-max), cm	175 (152–188)	170 (155–185)	176 (161–194)
Sex, male, female, n/N (%)	21/32 (66), 11/32 (34)	16/35 (46), 19/35 (54)	22/32 (69), 10/32 (31)
ASA, 1 ASA 2,* n/N (%)	20/32 (62), 12/32 (38)	23/35 (66), 12/35 (34)	19/32 (59), 13/32 (41)

*ASA classification of physical status.

supplementary anesthesia and postoperative analgesia, incidence of hypotension/bradycardia, and degree of satisfaction. Pairwise comparisons were done with Mann-Whitney *U* and Fisher exact tests. All analyses were performed with SAS software, version 9.2 (SAS System for Windows SAS Institute Inc).

RESULTS

The study flow chart is shown in Figure 1. Patients in all groups did not differ with respect to demographic and biometric data (Table 1). Given the imbalance in sex distribution, the groups have been compared using a stratified test as a sensitivity analysis. Results of the Wilcoxon test stratified on sex yielded comparable results ($P < 0.0001$ for comparisons with bupivacaine and $P = 0.008$ for the comparison between chloroprocaine and lidocaine).

Primary Endpoint

We observed a significant difference between the 3 groups in the time until complete recovery from sensory block (S5) (Fig. 2). The median time until complete recovery was 2.6 hours (interquartile range [IQR], 2.2–2.9 hours), 3.1 hours (IQR, 2.7;3.6 hours), and 6.1 hours (IQR, 5.5 hours to undefined) for chloroprocaine, lidocaine, and bupivacaine, respectively ($P < 0.0001$ for comparisons with bupivacaine and $P = 0.006$ for the comparison between chloroprocaine and lidocaine). Note that the upper limit is undefined because the point-wise confidence interval of the survival curve in the bupivacaine group did not reach 25%. After 3 hours, 93.8%, 84.4%, and 2.9% of patients were estimated to have a complete recovery of the sensory block, for chloroprocaine, lidocaine, and bupivacaine, respectively.

Secondary Endpoints

There was a significant difference in the time to complete recovery from motor block between the 3 groups (Fig. 3). The median time until recovery of the motor block was 1.48 hours (IQR, 1.32–1.8 hours), 1.83 hours (IQR, 1.56–2.17 hours), and 3.25 hours (IQR, 2–4.17 hours) for chloroprocaine, lidocaine, and bupivacaine, respectively. All pairwise comparisons were significant ($P < 0.0001$ for chloroprocaine vs bupivacaine, $P = 0.0004$ for lidocaine vs bupivacaine, and $P = 0.008$ for lidocaine vs chloroprocaine).

Voiding times were significantly ($P < 0.0001$) longer for bupivacaine when compared with lidocaine and chloroprocaine (Fig. 4). There was no evidence for a difference between lidocaine and chloroprocaine ($P = 0.69$). The ambulation times were significantly longer for bupivacaine compared with lidocaine and chloroprocaine, but there was no difference between lidocaine and chloroprocaine ($P = 0.199$) (Table 2). The discharge times were significantly longer for bupivacaine when compared with chloroprocaine. The comparison with lidocaine was not significant ($P = 0.02$, not significant

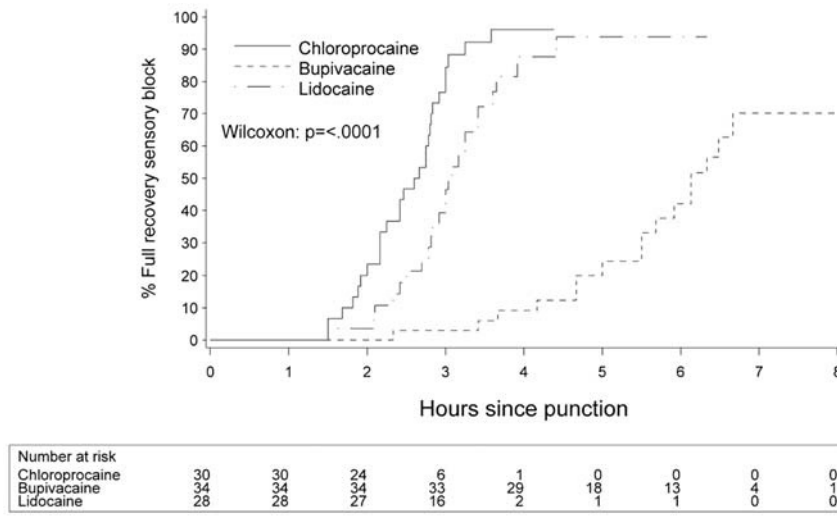

FIGURE 2. Cumulative distribution of the time until complete recovery from sensory block. Estimates are the complement of the Kaplan-Meier curve.

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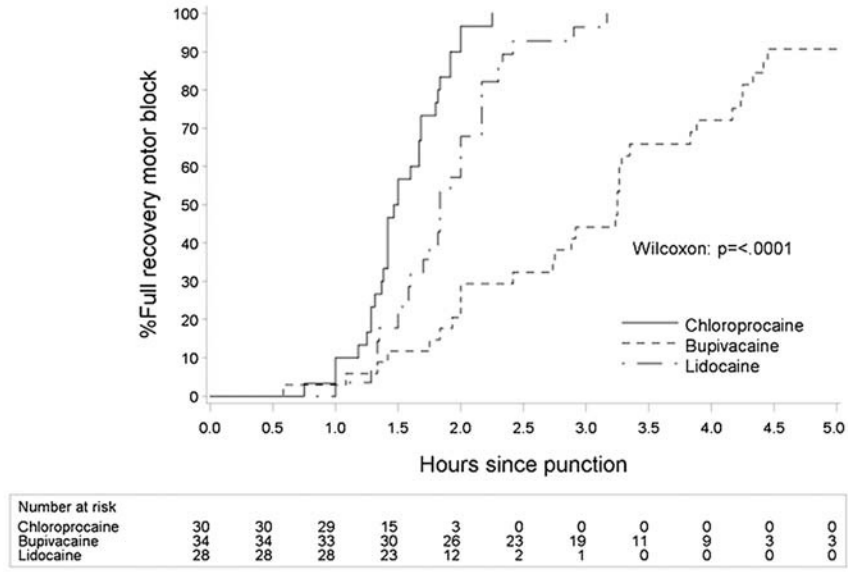

FIGURE 3. Cumulative distribution of the time until full recovery from motor block. Estimates are the complement of the Kaplan-Meier curve.

after Bonferroni correction). There was no evidence for a difference between lidocaine and chloroprocaine (P = 0.55) (Table 2). The use of rescue medication for postoperative analgesia was significantly lower for bupivacaine when compared with lidocaine and chloroprocaine (Table 3).

There was no evidence for a difference in the incidence of conversion to general anesthesia, intraoperative administration of analgesics, the incidence of bradycardia and/or hypotension, and in the degree of patient satisfaction (Table 2). No patient reported symptoms indicative for TNS.

DISCUSSION

In the present study investigating different local anesthetics for spinal anesthesia in patients undergoing ambulatory knee arthroscopy, 40 mg of chloroprocaine had the shortest recovery of complete sensory and motor block when compared with 40 mg of lidocaine and 7.5 mg of bupivacaine. These rapid recovery characteristics of chloroprocaine translated into a decrease in voiding times, ambulation times, and discharge times but a higher requirement for postoperative analgesia. However, for these clinically relevant endpoints, statistical significance could only be achieved for the differences between chloroprocaine and bupivacaine, but not for the comparison between chloroprocaine and lidocaine.

Of note, our study is the first that compared 2 fast-acting local anesthetics (chloroprocaine and lidocaine) with a long-acting reference (bupivacaine). In addition, we studied doses of local anesthetics that have been described to represent for the individual anesthetics the lowest dose with which a sufficient block height

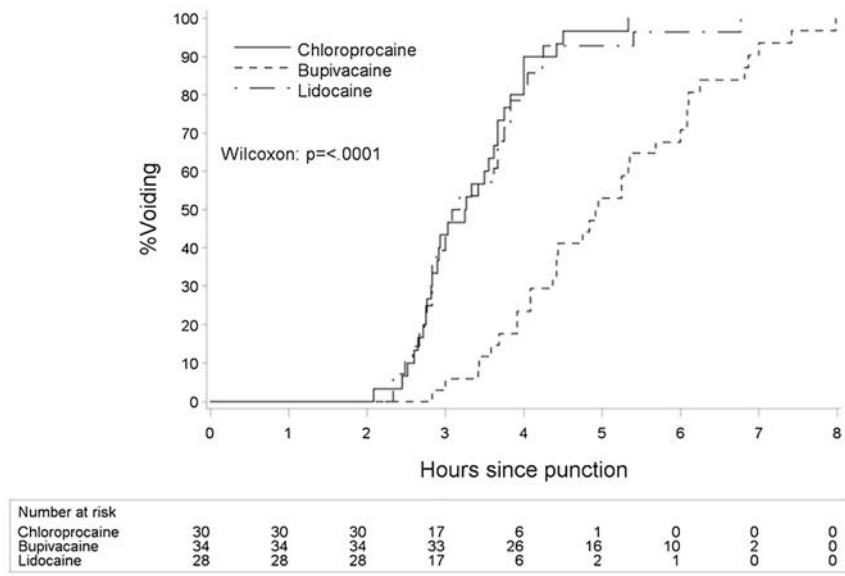

FIGURE 4. Cumulative distribution of the voiding times. Estimates are the complement of the Kaplan-Meier curve.

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TABLE 2. Perioperative Data

	Chloroprocaine	Bupivacaine	Lidocaine	*P*
Conversion to general anesthesia, n/N (%)	2/32 (6)	1/35 (3)	4/32 (13)	0.294
Incidence of hypotension, n/N (%)	2/30 (7)	0/34 (0)	1/28 (4)	0.293
Incidence of bradycardia, n/N (%)	1/30 (3)	0/34 (0)	1/28 (4)	0.529
Ambulation times, median (IQR), h	3.2 (2.8–3.8)	4.7 (3.9–5.7)*†	3.7 (3.0–4.1)	<0.001
Discharge times, median (IQR), h	4.4 (3.6–5.2)	5.8* (4.7.6.5)	4.6 (3.8–6.1)	0.004
Patient satisfaction (numeric rating scale score 0–10), median (min-max)	9 (3–10)	8.5 (1–10)	9 (8–10)	0.243

*$P < 0.05$ (0.01) versus chloroprocaine.
†$P < 0.05$ (0.01) versus lidocaine.

and duration can be achieved for knee arthroscopy. Kopacz[16] concluded that a dose of 40 to 60 mg has a reliable sensory block and motor block. In a clinical study by Casati et al,[18] 40 mg of chloroprocaine was shown to be the most ideal dose because lowering this dose resulted in insufficient duration of anesthesia, and a higher dose only resulted in an increased time for block recovery. The same findings were demonstrated by Sell et al.[17] In the review by Nair et al,[9] bupivacaine 7.5 mg was shown to be the most ideal dose for bilateral spinal anesthesia in ambulatory knee arthroscopy. Two volunteer studies by Kouri and Kopacz[20] and Yoos and Kopacz[21] could demonstrate the same clinical anesthetic efficacy with chloroprocaine 40 mg, lidocaine 40 mg, and bupivacaine 7.5 mg. These findings resulted in our choice of drug dose. Moreover, we diluted all local anesthetics to the same volume and exclusively used isobaric solutions. By this strategy, we compared equivalent dosing schemes that are not influenced by difference in potency, volumes, or tonicity.[22,23] This is in clear contrast to several previous reports in which solutions of different tonicity were compared and in which doses were tested for which equivalency remains ambiguous.[24,25]

Notably, the rapid recovery characteristics of chloroprocaine resulted in significantly shorter ambulation and discharge times when compared with bupivacaine, but not in comparison with lidocaine. Our results are confirmed by the findings of Casati et al,[19] who also observed no differences in discharge times between lidocaine and chloroprocaine when the criterion of voiding was included. In contrast, Breebaart et al[24] reported significantly shorter discharge times for chloroprocaine when compared with lidocaine. This discrepancy can be most probably attributed to the fact that in our study patients were deemed to be fit for discharge only once complete recovery from the sensory block had been achieved, whereas in the study of Breebaert et al,[24] patients were discharged once they were able to void and unassisted ambulation was possible.

In our study, the incidence of block failure was 7% among the 3 groups with the highest (although statistically not significant) incidence in the lidocaine group (12.5%). This rate is in accordance with observations from Camponovo et al[26] (6.9%) but significantly higher than overall reported in the literature (3.1%).[27] This difference is probably owing to varying definitions of block failure and to comparably low lidocaine doses used in our study.

Most probably because of the faster offset of the sensory block, patients in the lidocaine and chloroprocaine group required significantly more frequently and significantly more opioid analgesics postoperatively when compared with bupivacaine. This observation is confirmed by the findings of Lacasse et al[28] and Camponovo et al.[26] The higher consumption of opioids did not affect patient satisfaction scores or the need for antiemetic medication for the treatment of PONV after opioids had been given.

Interestingly, we did not detect a single patient suffering from TNS in neither group. While this finding confirms recent reports on the lack of neurotoxicity of the preservative-free chloroprocaine formulations,[12] it is in striking contrast to the literature reporting a mean incidence of TNS of 17% (0%–33%) for lidocaine.[6,29,30]

We are unable to elucidate the exact reasons why in our study lidocaine did not cause TNS but suggest that the routine

TABLE 3. Intraoperative and Postoperative Administration of Analgesics

				Chloroprocaine	Bupivacaine	Lidocaine	*P*
Intraoperative	Piritramide	Administered	n/N (%)	4/30 (13)	2/34 (6)	1/28 (4)	0.377
		Dose, mg	Median (min-max)	0.0 (0.0–2.0)	0.0 (0.0–2.0)	0.0 (0.0–2.0)	0.604
	Sufentanil	Administered	n/N (%)	4/30 (13)	6/34 (18)	3/28 (11)	0.755
		Dose, µg	Median (min-max)	0 (0–5)	0 (0–10)	0 (0–5)	0.822
	Ketorolac 30 mg	Administered	n/N (%)	25/30 (83)	25/34 (74)	19/28 (68)	0.372
	Paracetamol 2g	Administered	n/N (%)	27/30 (90)	31/34 (91.18)	22/28 (68)	0.337
Postoperative	Piritramide	Administered	n/N (%)	6/30 (20)	0/34 (0)*†	6/28 (21)	0.006
		Dose, mg	Median (min-max)	0.0 (0.0–4.0)	0.0 (0.0–0.0)*†	0.0 (0.0–6.0)	0.017
	Tramadol	Administered	n/N (%)	2/30 (7)	0/30 (0)	2/28 (7)	0.258
		Dose, mg	Median (min-max)	0.0 (0.0–50)	0 (0.0–0.0)	0.0 (0.0–100)	0.296

*$P < 0.05$ (0.01) versus chloroprocaine.
†$P < 0.05$ (0.01) versus lidocaine.

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use of paracetamol and/or ketorolac might have probably masked possible symptoms of TNS in our patients. Moreover, our study was not powered to detect a low incidence of TNS.

We acknowledge that our study suffers from several limitations. First, in the majority of the available studies, patients are discharged once recovery from motor block has been obtained, and both ambulation and spontaneous micturition are possible. In order to exactly describe the clinical pharmacokinetics of chloroprocaine, our patients were discharged home only once a complete recovery of sensory block had been achieved. This criterion might have delayed the discharge times in comparison with other studies. However, also voiding and ambulation times were not significantly different between chloroprocaine and lidocaine. Second, our fluid regimen was not standardized. While all patients received a bolus of 250 mL of crystalloids preoperatively, intraoperative and postoperative fluid management was left at the discretion of the attending anesthesiologist. Likewise, postoperative oral fluid intake was on demand of the patient. We are therefore unable to exclude the theoretical possibility that differences in fluid management might have affected the observed differences in voiding times. However, intravenous fluid regimen has been considered by several authors not to affect voiding times after spinal anesthesia.[31,32] Obviously, the most important factors affecting voiding times and urinary retention are local anesthetic potency and dose.[31] Moreover, our data are in line with the results of studies in which fluid management was standardized and bladder volumes were measured.[24,25] A third limitation is the use of lower concentrations of local anesthetics, especially for bupivacaine, which were used in our study compared with other clinical trials. Although van Zundert et al[33] and Sheskey et al[34] concluded that the major determining factor for block height, motor block, and block duration is the dose of the local anesthetic and not the volume or the concentration.

Finally, our study has only been powered for the primary endpoint. The conclusions made of our secondary outcomes should therefore be interpreted with caution and cannot be generalized.

In conclusion, in patients undergoing spinal anesthesia for ambulatory knee arthroscopy, chloroprocaine 40 mg had the shortest time until complete recovery of sensory and motor block when compared with lidocaine 40 mg and bupivacaine 7.5 mg. Voiding, ambulation, and discharge times were shorter for chloroprocaine when compared with bupivacaine, but not in comparison with lidocaine. The use of rescue medication for postoperative pain was significantly lower for bupivacaine compared with lidocaine and chloroprocaine. There were no differences in adverse events or the incidence of TNS between the 3 groups.

This suggests that for spinal anesthesia in patients undergoing ambulatory knee arthroscopy chloroprocaine is a good alternative for bupivacaine. In our setting in which the incidence of TNS was zero, chloroprocaine had no clinically relevant superiority compared with lidocaine.

ACKNOWLEDGMENTS

The authors thank Christel Huygens, their study nurse, for her invaluable assistance.

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