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Prospective Study of the Incidence of Transient Radicular Irritation in Patients Undergoing Spinal Anesthesia

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Background: **There is considerable controversy regarding the role of subarachnoid 5% hyperbaric lidocaine in the syndrome transient radicular irritation (TRI). This randomized, double-blinded, prospective study was designed to determine the incidence of TRI and identify factors possibly contributing to its development.**

Methods: **One hundred fifty-nine ASA physical status 1 or 2 patients undergoing outpatient knee arthroscopy or unilateral inguinal hernia repair were prospectively randomized to receive spinal anesthesia with 5% hyperbaric lidocaine with epinephrine (60 mg with 0.2 mg epinephrine for arthroscopy or 75 mg with 0.2 mg epinephrine for hernia repair), 2% isobaric lidocaine without epinephrine (60 mg for arthroscopy or 75 mg for hernia repair), or 0.75% hyperbaric bupivacaine without epinephrine (7.5 mg for arthroscopy or 9.0 mg for hernia repair) in a double-blinded fashion. On the 3rd postoperative day, patients were contacted by a blinded investigator and questioned regarding the incidence of postoperative complications including TRI, defined as back pain with radiation down one or both buttocks or legs occurring within 24 h after surgery. Postoperatively, time from injection to block resolution, ambulation, voiding, and ready for discharge were recorded by a postanesthesia care unit nurse blinded to the group assignment.**

Results: **The incidence of TRI was greater in patients receiving lidocaine than in those receiving bupivacaine (16% *vs.* 0%; $P = 0.003$). There was no difference in the incidence of TRI between the patients receiving 5% hyperbaric lidocaine with epinephrine and those receiving 2% isobaric lidocaine without epinephrine (16% *vs.* 16%; $P = 0.98$). The incidence of TRI was greater in patients undergoing arthroscopy than in those undergoing hernia repair (13% *vs.* 5%; $P = 0.04$). There was no difference in discharge times in patients receiving bupivacaine *versus* those receiving hyperbaric lidocaine with epinephrine (292 *vs.* 322 min; $P = 0.61$).**

Conclusions: **The incidence of TRI is greater with lidocaine than bupivacaine, decreasing the lidocaine concentration to 2% does not prevent TRI, and surgical position may be an important contributing factor. Discharge times at our institution are not different when equipotent doses of 0.75% hyperbaric bupivacaine or 5% hyperbaric lidocaine with 0.2 mg epinephrine are used in ambulatory patients undergoing spinal anesthesia. (Key words: Anesthetics, local: bupivacaine; lidocaine. Anesthetic techniques: spinal. Cauda Equina syndrome. Pain: radicular. Transient radicular irritation. Outpatient.)**

SINCE the initial prospective study by Phillips *et al.* in 1969[1] of 10,000 patients undergoing spinal anesthesia, 5% hyperbaric lidocaine has enjoyed widespread popularity and an impressive safety record. Recently there has been controversy regarding the use of subarachnoid hyperbaric lidocaine and its potential association both with cauda equina syndrome during continuous spinal anesthesia[2,3] and as a possible causative agent in the poorly defined syndrome transient radicular irritation (TRI).[4–6]

Reports published in 1991[2,7] of cauda equina syndrome after continuous spinal anesthesia led to scrutiny of lidocaine as a potential neurotoxic agent. Of these initial case reports of cauda equina syndrome, all but one involved the use of lidocaine.[2,7,8] It was postulated, however, that the mechanics of microcatheters (which reputedly allowed pooling of local anesthetics at the lumbosacral roots) and large doses of local anesthetics were more to blame for cauda equina syndrome than toxicity specific to the local anesthetic. Subsequently, microcatheters were withdrawn from the market.§

In 1993, Schneider *et al.*[9] published four case reports of transient neurologic toxicity after spinal anesthesia with 5% hyperbaric lidocaine. An accompanying editorial[3] questioned the continued use of 5% hyper-

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§ FDA Safety Alert: Cauda Equina Syndrome Associated with Use of Small-bore Catheters in Continuous Spinal Anesthesia. Washington, DC, Food and Drug Administration, May 29, 1992.

baric lidocaine because of potential neurotoxicity. Later that year, Hampl *et al.*[4] reported a prospective, nonrandomized study in which patients received either 5% hyperbaric lidocaine, 0.5% hyperbaric bupivacaine, or 0.5% isobaric bupivacaine (all without epinephrine) for spinal anesthesia and were assessed for postoperative neurologic complications. Hampl defined TRI as pain and/or dysesthesia after recovery from spinal anesthesia and resolving within 72 h. This group reported a 37% incidence of TRI in patients receiving 5% hyperbaric lidocaine and no occurrences in patients receiving bupivacaine.[10]

To date, the published information on the possible neurologic complications of single-dose spinal hyperbaric lidocaine has been exclusively anecdotal case reports[5,6] and retrospective or nonrandomized reviews. This prospective, double-blinded, randomized study was designed to determine the incidence of postoperative TRI in healthy ambulatory surgery patients undergoing spinal anesthesia for knee arthroscopy or inguinal hernia repair.

Methods and Materials

After Institutional Review Board approval, informed consent, and power analysis, 159 ASA physical status 1 or 2 patients undergoing outpatient arthroscopy or herniorrhaphy were randomized and stratified in a double-blinded fashion to receive 5% hyperbaric lidocaine (Abbott, North Chicago, IL) with 0.2 mg epinephrine, 2% isobaric lidocaine (Abbott), or 0.75% hyperbaric bupivacaine (Astra, Westborough, MA) in equipotent doses.[7] The number of patients to be enrolled in this study was determined by power analysis (80%; $P = 0.05$) performed after a retrospective chart review of patients undergoing outpatient spinal anesthesia at our institution who postoperatively complained of back pain. The incidence of back pain in this review was 15%. Patients were divided into two groups based on surgical procedure and randomized by sealed envelope. Patients undergoing knee arthroscopy (n = 100) received either 60 mg lidocaine (1.2 ml hyperbaric 5% lidocaine or 3.0 ml isobaric 2% lidocaine) or 7.5 mg bupivacaine (1.0 ml), whereas patients undergoing unilateral hernia repair (n = 59) received either 75 mg lidocaine (1.5 ml hyperbaric 5% lidocaine or 3.75 ml isobaric 2% lidocaine) or 9 mg bupivacaine (1.2 ml).

Preoperatively, patients received a peripheral intravenous infusion with lactated Ringer's solution. Patients were sedated with intravenous midazolam (Roche, Manati, PR) in a mean dose of 0.03 μg/kg (range 0.01–0.08 mg/kg) and fentanyl (Janssen, Titusville, NJ) in a mean dose of 2 μg/kg (range 0.5–4 μg/kg) at the discretion of the attending anesthesiologist. Spinal anesthesia was performed at the L2–L3 or L3–L4 interspace with the patient in the lateral decubitus position using a 22- or 25-G Quincke, Greene, or Whitacre needle. Patients received supplemental oxygen and were monitored with electrocardiography, automated blood pressure, and pulse oximetry. Hypotension (systolic blood pressure < 90 mmHg or a >20% decrease from baseline) was treated with 5-mg increments of ephedrine or 100-μg increments of phenylephrine. Bradycardia (heart rate < 50 beats/min or a >20% decrease from baseline) was treated with 0.4 mg atropine. Nausea was treated with 5 mg ephedrine or 10 mg metoclopramide. Average block heights for herniorrhaphy patients were T6 for patients receiving 2% lidocaine or 0.75% bupivacaine and T5 for patients receiving 5% lidocaine. In arthroscopy patients, the average block height was T7 for patients receiving 2% lidocaine or 0.75% bupivacaine and T5 for patients receiving 5% lidocaine. Further intraoperative sedation was provided as needed with midazolam (mean dose 0.02 μg/kg) or a continuous infusion of 0.2% methohexital.

Data on patient demographics, degree of difficulty, and time required for block placement, paresthesias, patient position during block placement, needle bevel or orifice direction, needle type, surgical position, duration of surgery, adequacy of the block for surgery, and use of ketorolac (Syntex, Palo Alto, CA) were collected. Time from injection until block resolution, voiding, ambulation, and time to ready for discharge were checked at 15-min intervals and recorded. There was no attempt to stratify patients by surgical attending physician. Six general surgeons performed herniorrhaphy, and five orthopedic surgeons performed arthroscopy. Time to block resolution was defined as the time that a blinded PACU nurse could no longer detect presence of anesthesia to pinprick or alcohol swab. Time to ambulation was the time at which the patients believed they had normal sensation of their buttocks and feet and were able to ambulate successfully. Time to void was noted at the first successful trial of voiding. Requests to attempt voiding began with the ability to ambulate. Discharge time was the time the patient had fulfilled all standard institutional discharge criteria (modified

Table 1. Demographic Data

	2% Lidocaine (N = 20)	5% Lidocaine (N = 20)	0.75% Bupivacaine (N = 19)
Hernia patients (N = 59)			
Males	16	16	16
Females	0	3	3
Age (yr)	59 ± 17	53 ± 12	62 ± 14
Weight (kg)	81 ± 13	83 ± 13	81 ± 18
Failed block	4	1	0
	(N = 35)	(N = 32)	(N = 33)
Arthroscopy patients (N = 100)			
Males	22	17	14
Females	13	15	17
Age (yr)	51 ± 13	52 ± 16	50 ± 16
Weight (kg)	82 ± 15	91 ± 27	79 ± 19
Failed block	0	0	2

Aldrete and postanesthesia discharge scoring system score 8–10).

On the 3rd postoperative day, patients completed a telephone interview with a blinded investigator whereby they were questioned regarding the presence of backache with or without radiation into the buttocks or legs, difficulty with ambulation, degree of activity, and pain control. For this study, TRI was defined as back pain with radiation to one or both buttocks or legs and beginning within 24 h of surgery. Patients were questioned regarding the onset, duration, and treatment used for any symptoms. Pain was assessed using a verbal pain rating scale (0–10). Back pain without radiation down one or both legs was not considered to be TRI but was recorded separately.

Differences in the incidence of TRI, back pain without radiation down the legs, patient variables (gender, weight, and age), and anesthetic factors (needle type, difficulty of block placement, or paresthesia) were analyzed separately using chi-square analysis of contingency tables. Differences in the duration of anesthesia, time to block resolution, time to ambulation, time to void, and time to discharge were assessed using analysis of variance with Scheffé's F test for *post hoc* comparisons. Significance was defined as $P < 0.05$. Results are expressed as actual number of occurrences, percentage, and/or mean ± SD.

Results

Demographics were comparable between groups (table 1). There were three postdural puncture headaches, and two patients required epidural blood patch. Seven blocks provided inadequate surgical anesthesia. Four of these occurred in the isobaric lidocaine hernia group, one in the hyperbaric lidocaine hernia group, and two in the bupivacaine arthroscopy group. None of the seven subjects with inadequate spinal anesthesia reported TRI, but these patients were excluded from the final data analysis because of the possibility that local anesthetic was not placed intrathecally.

Incidence of TRI

The incidence of back pain with radiation down one or both legs (TRI) differed ($P = 0.003$) between patients receiving lidocaine (16%) and those receiving bupivacaine (0%; table 2). There was no difference in the incidence of TRI between the patients receiving 5% hyperbaric lidocaine with 0.2 mg epinephrine (16%) and those receiving 2% isobaric lidocaine (16%). The incidence of TRI was significantly greater ($P = 0.04$) in patients undergoing arthroscopy (13%) than in those undergoing hernia repair (5%).

There was no association between the incidence of TRI and patient gender, weight, or age. Additionally,

Table 2. Incidence of TRI

	Lidocaine 2% (N = 51)	Lidocaine 5% (N = 51)	Bupivacaine 0.75% (N = 50)
TRI			
All patients	8 (16%)	8 (16%)	0 (0%)
Hernia	0 (0%) N = 16	3 (16%) N = 19	0 (0%) N = 19
Arthroscopy	8 (22%) N = 35	5 (16%) N = 32	0 (0%) N = 31
Non-TRI back pain			
All patients	3 (6%)	10 (20%)	4 (8%)
Hernia	0 (0%) N = 16	2 (11%) N = 19	1 (5%) N = 19
Arthroscopy	3 (9%) N = 35	8 (25%) N = 32	3 (10%) N = 31

there was no association between TRI and needle type, the difficulty of block placement, or paresthesias.

Characteristics of TRI

Of the 16 patients who reported back pain with radiation down one or both legs, 3 had undergone hernia repair and 13 had undergone arthroscopy (chi-squared, $P = 0.04$; table 3). Fourteen patients reported bilateral symptoms. Two patients reported unilateral symptoms only, and both of these patients had undergone arthroscopy and were symptomatic in the operative extremity. Patients reported an onset of TRI within 12–24 h of surgery and a duration between 6 h and 4 days. The average verbal rating pain score for patients reporting TRI (scale 1–10) was 6.2 (range 1–9). Fourteen of 16 patients stated that their radicular irritation was worse than their incisional pain. Most described only moderate pain relief with nonsteroidal antiinflammatory drugs or the oral opioids prescribed postoperatively by their surgeons. No patients exhibited permanent neurologic sequelae or continued symptoms at 2-week followup.

Discharge Data

Average time from spinal anesthesia to ready for discharge was 277 min for patients undergoing arthroscopy and 337 min for patients having unilateral inguinal hernia repair. In arthroscopy patients (fig. 1), times to block resolution and ambulation were significantly faster with 0.75% hyperbaric bupivacaine (195 and 212 min, respectively) and 2% isobaric lidocaine (194 and 209 min, respectively) than with 5% hyperbaric lidocaine with epinephrine (234 and 246 min, respectively). However, there were no differences in actual time to ready for discharge ($P = 0.9$).

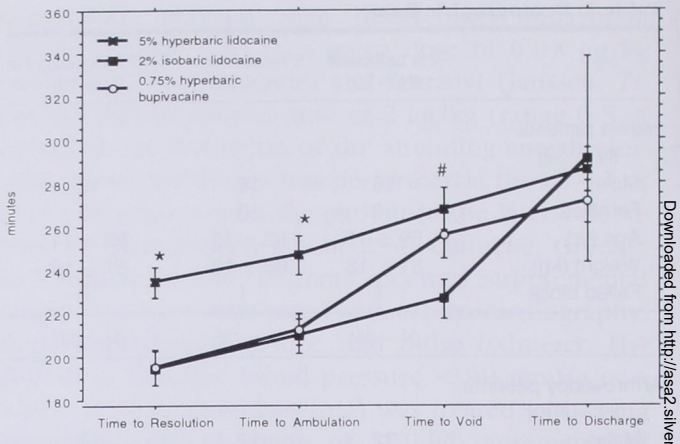

Fig. 1. Time to block resolution, ambulation, voiding, and ready for discharge in patients undergoing spinal anesthesia for arthroscopy with 5% hyperbaric lidocaine with 0.2 mg epinephrine, 2% isobaric lidocaine without epinephrine, or 0.75% hyperbaric bupivacaine without epinephrine. *$P < 0.02$ hyperbaric lidocaine *versus* isobaric lidocaine & hyperbaric lidocaine vs bupivacaine. #$P < 0.02$ hyperbaric lidocaine *versus* isobaric lidocaine only.

For herniorrhaphy patients, differences occurred at every interval when comparing 5% hyperbaric lidocaine with 0.2 mg epinephrine *versus* 2% isobaric lidocaine (fig. 2). There were no statistically significant

Table 3. Characteristics of Patients with Transient Radicular Irradiation

Age (yr)/Sex	Local Agent	Surgery	Onset (h)	Duration	VPRS	Description
41/M	2% lidocaine	Arthroscopy	12	36 h	6	Burning
46/F	2% lidocaine	Arthroscopy	12	2 days	4	Spasm
42/F	2% lidocaine	Arthroscopy	12	4 days	8	Sciatic
38/M	2% lidocaine	Arthroscopy	6	2 days	4	
44/M	2% lidocaine	Arthroscopy	6	12 h	8	Radiating
64/F	2% lidocaine	Arthroscopy	8	2 days	8	
46/M	2% lidocaine	Arthroscopy	18	6 h	1	
80/M	2% lidocaine	Arthroscopy	6	4 days	8	Aching
29/M	5% lidocaine	Arthroscopy	18	2 days	8	Aching
72/F	5% lidocaine	Arthroscopy	8	1 day		Sciatic
26/F	5% lidocaine	Arthroscopy	24	3 days	7	Cramps
47/M	5% lidocaine	Arthroscopy	18	2 days	7	Aching
30/M	5% lidocaine	Arthroscopy	18	1 day	4	
57/M	5% lidocaine	Herniorrhaphy	8	2 days	9	Toothache
68/M	5% lidocaine	Herniorrhaphy	8	2 days	6	Aching
73/M	5% lidocaine	Herniorrhaphy	12	2 days	6	Burning

VPRS = Verbal Pain Rating Score.

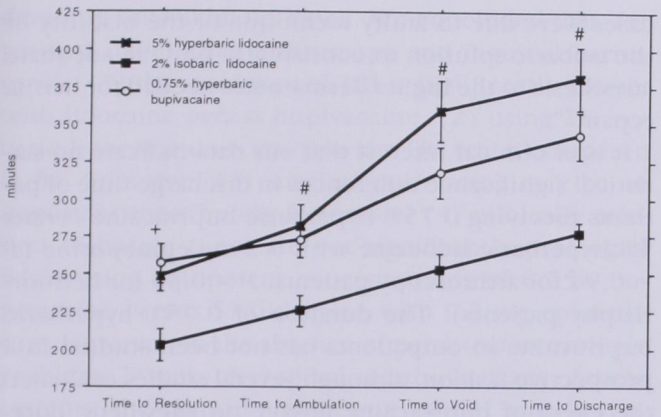

Fig. 2. Time to block resolution, ambulation, voiding, and ready for discharge in patients undergoing spinal anesthesia for inguinal hernia repair with 5% hyperbaric lidocaine with 0.2 mg epinephrine, 2% isobaric lidocaine without epinephrine, or 0.75% hyperbaric bupivacaine without epinephrine. $+P < 0.03$ hyperbaric lidocaine *versus* isobaric lidocaine and bupivacaine *versus* isobaric lidocaine. $\#P < 0.02$ hyperbaric lidocaine *versus* isobaric lidocaine only.

differences at any interval between 0.75% hyperbaric bupivacaine and 5% hyperbaric lidocaine with epinephrine. Statistical differences between bupivacaine and 2% isobaric lidocaine were significant only at time of block resolution (bupivacaine 257 min, isobaric lidocaine 202 min; $P = 0.008$).

Discussion

This is the first randomized, prospective, double-blinded study to demonstrate a difference in the incidence of TRI when using subarachnoid lidocaine *versus* bupivacaine, that both 5% hyperbaric and 2% isobaric lidocaine are associated with TRI, and that type of surgery or surgical position may play a role in TRI. Possible causes of TRI include a specific local anesthetic toxicity, needle trauma, neural ischemia secondary to sciatic stretching, patient positioning, or pooling of local anesthetics secondary to small-gauge pencil-point needles. Because no patient in our study receiving intrathecal bupivacaine reported TRI, it appears that TRI is not the result of having a subarachnoid block *per se*. Hence, epiphenomena of a subarachnoid block (*e.g.*, spinal needle placement, relaxation of lumbar musculature, or surgery) are not sole etiologic factors of TRI. The only difference between groups in our study was the local anesthetic bupivacaine or lidocaine. Thus, the use of lidocaine appears to correlate with the development of TRI. These findings are consistent with previously published laboratory animal studies and case reports.

Our experimental design attempted to eliminate relative anesthetic potency as a possible cause of TRI. Equipotency of bupivacaine *versus* lidocaine was determined based on work completed by Langerman *et al.*[11] using partition coefficients as a predictor of intrathecal local anesthetic potency. Langerman *et al.* used the intrathecal mouse model to determine the ED_{50} for analgesic effect on the tail-flick test. Initial results by this group during our protocol development[12] revealed an anesthetic potency for bupivacaine to lidocaine of 8:1. Subsequently, the study was amended to predict a potency of 9:1. Using the initial findings of Langerman *et al.*'s study, we concluded that 7.5 and 9 mg bupivacaine were equipotent to 60 and 75 mg lidocaine, respectively. Doses were selected based on this potency data and in an attempt to replicate actual clinical practice. Nevertheless, the applicability of potency studies in the intrathecal rat model to patients undergoing spinal anesthesia is inconclusive.

Epinephrine was specifically included in only patients receiving 5% hyperbaric lidocaine in an attempt to determine whether the addition of epinephrine might increase the incidence of TRI. There was not a higher incidence of TRI in the patients receiving 5% hyperbaric lidocaine with epinephrine (16%) than in the group receiving 2% isobaric lidocaine without epinephrine (16%).

Laboratory investigations examining the effects of specific local anesthetics on isolated nerves have included studies of local anesthetics in various concentrations.[13–15] Lambert evaluated the neurotoxic potential of commercially available local anesthetics used for spinal anesthesia. In the sciatic nerve preparation, 5% hyperbaric lidocaine, 0.5% tetracaine and 0.75% bupivacaine caused nonreversible ablation of the stimulated compound action potential, whereas the membrane resting potential remained intact. Thus, local anesthetics impaired nerve function without physically destroying them. In a subsequent paper, the same group[14] evaluated varying concentrations of lidocaine to determine the concentration below which neural injury does not occur. In this study, lidocaine induced a nonreversible loss of impulse activity in frog nerve in a progressive dose-dependent fashion beginning at 40 mmol. There was complete ablation of activity at 80 mmol lidocaine. This 80-mmol concentration is equivalent to the clinically available concentration of

2.0% lidocaine. An additional laboratory study related to the safety of lidocaine was performed by Sakura *et al.*[16] This group attempted to determine the contribution of 7.5% glucose to the neurotoxicity of 5% lidocaine in the rat model. The addition of glucose did not affect the potential of intrathecally administered 5% lidocaine to induce sensory impairment.

Many aspects of the aforementioned *in vitro* studies and clinical reports[17] are consistent with our data, particularly our finding that decreasing the concentration of lidocaine from 5% to 2% did not prevent the development of TRI. In equipotent anesthetic doses, we observed a 16% incidence of transient radicular symptoms in patients receiving lidocaine spinal anesthesia regardless of the addition of glucose and in concentrations of lidocaine as low as 2%.

The potential interaction between local anesthetics and the type of surgery or surgical positioning is interesting. The original case report of TRI by Schneider *et al.*[9] described four patients undergoing 5% hyperbaric lidocaine spinal anesthesia while in the lithotomy position. The authors speculated that this position may contribute to TRI by stretching the cauda equina and the sciatic nerve, thus decreasing the vascular supply and increasing the vulnerability to injury. This interaction may be compounded in the lithotomy position, where flattening of the lumbar curvature exposes the sacral fibers to the highest concentration of local anesthetic. This theory may be supported by the higher incidence of TRI we found in patients undergoing arthroscopy (13%) *versus* those having inguinal hernia repair (5%). In our institution, arthroscopy patients have their nonoperative leg straight at the hip, and flexed 90° at the knee. The operative leg position is varied throughout the surgery to obtain the best views of the knee joint. It is possible that this positioning or manipulation may contribute to neural stretching and the subsequent development of TRI.

Finally, we examined discharge data in an effort to learn whether 2% isobaric lidocaine or 0.75% hyperbaric bupivacaine could be an acceptable alternative to 5% hyperbaric lidocaine with 0.2 mg epinephrine in outpatients undergoing spinal anesthesia for inguinal hernia repair or arthroscopy. Patients receiving 2% isobaric lidocaine had the fastest recovery and discharge times of the groups we studied; however, isobaric lidocaine proved to be a difficult drug to use for inguinal hernia repair, because there were four cases of anesthesia inadequate for incision in this group (20%). It is impossible to determine with certainty whether these cases were due to faulty technique or the inability of the isobaric solution to consistently provide adequate anesthesia to the higher dermatomes needed for hernia repair.[18]

It is of clinical interest that our data indicate no statistical significance differences in discharge time of patients receiving 0.75% hyperbaric bupivacaine *versus* 5% hyperbaric lidocaine with 0.2 mg epinephrine ($P = 0.94$ for arthroscopy patients, $P = 0.30$ for herniorrhaphy patients). The duration of 0.75% hyperbaric bupivacaine in outpatients has not been studied in a prospective fashion, although several studies evaluated the effect of bupivacaine dosage on anesthetic duration.[19–22] Because bupivacaine does not appear to prolong time to ready for discharge when compared to 5% hyperbaric lidocaine with 0.2 mg epinephrine, its use may be considered in outpatients undergoing inguinal hernia repair or arthroscopy.

Several limitations to our study design must be recognized. First, 159 patients is a small number for a clinical study. Although it was an appropriate number as determined by power analysis and a number that allowed statistical significance to be achieved, it must be acknowledged as a small sample size. Also, there were not equal numbers of patients in the hernia *versus* arthroscopy group. During protocol development, we had not anticipated a difference in the incidence of TRI based on surgical procedure or positioning; therefore, no attempt was made to equalize the numbers of patients having the two different types of surgery. Only after the study was completed and the code was broken did we recognize the potential impact of the type of surgical positioning. Additionally, several surgeons participated in this study; therefore, differing surgical techniques cannot be ruled out as a contributing factor in the development of TRI. Finally, three different types of spinal needles were used to perform anesthesia in this study. In keeping with our current clinical practice, to reduce the incidence of postdural puncture headache, patients older than age 65 yr received spinal anesthesia with a beveled needle (Greene or Quincke), and patients younger than age 65 yr received spinal anesthesia with a pencil point needle (Whitacre). And, although there was no correlation with needle type and the development of TRI, it was not a variable that was strictly controlled; therefore needle design also cannot be eliminated as a contributing factor.

In conclusion, this is the first prospective, randomized double-blinded study to determine the incidence of TRI and discharge data in ambulatory patients un-

dergoing subarachnoid block. We concluded that, for patients undergoing arthroscopy and inguinal hernia repair, (1) the incidence of TRI is significantly greater with lidocaine *versus* bupivacaine, (2) using 2% isobaric lidocaine does not prevent TRI when compared to 5% lidocaine, (3) surgical positioning may be an important contributing factor, and (4) clinically relevant discharge times are not significantly prolonged when using equipotent concentrations of 0.75% bupivacaine *versus* 5% lidocaine with 0.2 mg epinephrine. However, in the absence of persistent neurologic problems 2 weeks after spinal anesthesia in any of these patients, the clinical significance of TRI remains unclear and warrants further investigation.[23]

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