Effects of intrathecal fentanyl on duration of bupivacaine spinal blockade for outpatient knee arthroscopy

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The purpose of this study was to determine if intrathecal fentanyl speeds the onset and prolongs the duration of sensory and motor block, prolongs the duration of postoperative analgesia, or increases the incidence of adverse effects in patients undergoing spinal anesthesia for outpatient knee arthroscopy. Fifty patients were randomized to receive 12 mg of hyperbaric bupivacaine 0.75% with 25 µg (0.5 mL) of fentanyl (group 1) or 12 mg of hyperbaric bupivacaine 0.75% with 0.5 mL of preservative-free normal saline (group 2). One-tailed t tests were used to determine differences in onset and duration of sensory or motor block. Group 1 experienced significantly better postoperative analgesia lasting more than 3 hours longer than analgesia for group 2. Group 1 demonstrated significantly more pruritus, but there were otherwise no differences. We conclude that fentanyl does not enhance the onset and duration of sensory or motor block produced by 12 mg of intrathecal bupivacaine. Fentanyl, however, prolongs postoperative analgesia and increases the risk of pruritus.

Key words: Analgesics, bupivacaine, intrathecal fentanyl, local anesthetics.

Introduction

The specific aims of the present study were to determine if fentanyl speeds the onset and prolongs the duration of bupivacaine spinal block, prolongs the duration of postoperative analgesia, or increases the incidence of adverse effects in patients undergoing outpatient knee arthroscopy. Regional techniques, such as spinal anesthesia, may offer advantages over general anesthesia including reduced stress response to surgery and improved postoperative pain relief.1

Intrathecal local anesthetics work by inhibiting voltage-gated sodium channels in the spinal cord, which interferes with afferent and efferent sensory and motor impulses. The degree of sensory and motor block depends on the technique, agent, and dose administered.7 Opioids work in the intrathecal space by activating opioid receptors in the dorsal gray matter of the spinal cord, which modulates the function of afferent pain fibers. Numerous studies support the combination of local anesthetics with opioids to provide safe anesthesia and analgesia while reducing the required doses and adverse effects of each agent.1

Intrathecal and epidural narcotics seem to modulate pain primarily at the spinal cord rather than in the brain, as do intravenous narcotics.7 The blood and cerebrospinal fluid concentrations of fentanyl following epidural administration depend more on spinal cord absorption than systemic absorption. A site of action in the spinal cord may provide analgesia with less sedation, confusion, and nausea, which are adverse effects often associated...
with intravenous narcotics. Fentanyl may be synergistic with bupivacaine in reducing pain without measurably increasing sympathetic or motor blockade in dog models.

Intrathecal sufentanil, which has the same mechanism of action but different pharmacokinetics compared with fentanyl, significantly \( P < .05 \) prolonged analgesia when combined with hyperbaric bupivacaine in patients undergoing cesarean section. One study compared intrathecal fentanyl mixed with hyperbaric bupivacaine with bupivacaine alone in patients undergoing lower extremity or genitourinary surgery. The fentanyl group demonstrated significantly \( P < .05 \) longer duration of sensory block and less postoperative pain without an increased duration of the motor block. The fentanyl group demonstrated significantly \( P < .05 \) more hypotension, but there were otherwise no significant differences in adverse effects. One large problem with the study was that patients underwent different surgical procedures at different anatomic sites ranging from inguinal hernia repairs to vascular and orthopedic procedures of the lower extremities. The benefits and risks of intrathecal fentanyl may be better measured in patients undergoing the same surgical procedure.

The goals of the present study were to determine if the combination of intrathecal fentanyl and bupivacaine affects the onset and duration of somatomotor block and improves postoperative pain relief without causing clinically significant adverse effects compared with bupivacaine alone. It has been stated that at least 20 \( \mu \)g of intrathecal fentanyl were needed to provide satisfactory postoperative analgesia in elderly patients undergoing lower extremity revascularization procedures. Fentanyl is generally less expensive than sufentanil, and there is a lower incidence of prolonged adverse effects, such as respiratory depression following discharge, that can occur with other opioids.

Our study used methods similar to those used by Singh et al, but there were key differences. We standardized our patient population to arthroscopic knee surgery in an effort to create similar degrees of surgical trauma. Second, we reduced the dosage of local anesthetic to determine if postoperative motor blockade could be lessened while providing adequate perioperative sensory blockade and postoperative analgesia.

**Methods**

After we received institutional review board approval, 50 men and women between the ages of 18 and 65 years undergoing elective outpatient arthroscopic knee surgery for medial meniscus repair consented to participate in the study, which was conducted at a large military teaching hospital that has an orthopedic surgical residency program.

Patients were randomly assigned to 1 of 2 groups using a computer-generated random number table. An intravenous line was started while patients were in the preoperative holding area, written consent for study participation was obtained, and patients were administered from 1 to 4 mg of midazolam intravenously. Once patients stated that they felt relaxed and ready to proceed, they were brought to the operating room, and baseline vital signs were obtained. Patients received a standard bolus of lactated Ringer’s, 10 mL/kg, while they were in the preoperative holding area to help maintain adequate venous return following onset of the spinal anesthetic. No analgesics or customary intra-articular bupivacaine were administered before or during surgery.

Double-blind randomization was accomplished by having 1 anesthetist open the group assignment envelope and prepare a syringe of 1.6 mL (12 mg) of 0.75% hyperbaric bupivacaine with 0.5 mL (25 \( \mu \)g) of fentanyl (group 1; \( n = 27 \)) or 1.6 mL (12 mg) of 0.75% hyperbaric bupivacaine with 0.5 mL of preservative-free normal saline (group 2; \( n = 23 \)). Another anesthetist performed the subarachnoid block and collected data. Only the anesthetist preparing the solution was aware of the syringe contents.

Patients were placed in the lateral decubitus position with the operative side down for administration of the spinal anesthetic. An 18-gauge introducer followed by a 24-gauge Sproule needle was placed in the L2-3 or L3-4 interspace. Once cerebrospinal fluid was determined to be free-flowing from the needle, the solution was injected following gentle aspiration and observation of the cerebrospinal fluid “swirl.” Patients were immediately repositioned supine following injection. Blood pressures were monitored every 5 minutes in the operating room and every 15 minutes in the postanesthesia care unit.

To assess differences in onset of sensory and motor block, patients were assessed every 2 minutes for 10 minutes following subarachnoid block injection. Sensory block was assessed by cold perception using alcohol-soaked gauze. Assessments were timed to record the highest dermatomal levels achieved, as well as the time needed to establish a stable block. Motor block also was assessed every 2 minutes by asking the patient to move the foot and bend the knee on the operative side until surgery began. The degree of motor block was assigned by using the Bromage classification as follows:

\[
0 = \text{No impairment of leg and foot movement}
\]
1 = Barely able to flex the knee; no impaired foot movement
2 = Unable to flex the knee; barely able to move the foot
3 = Unable to move the foot or the knee

Sensory and motor block were assessed on admission and every 15 minutes in the postanesthesia care unit until Bromage class 0 and recovery of sensation to the T10 level were achieved (criteria for postanesthesia care unit discharge to the same day surgery ward). Along with sensorimotor block, adverse effects and pain were assessed every 15 minutes in the operating room and in the postanesthesia care unit. Hypotension was determined as a 20% reduction in baseline mean arterial pressure. Bradycardia (20% reduction in baseline heart rate), respiratory depression (respirations < 10 per minute), nausea or vomiting, pruritus, and pain were assessed at least every 15 minutes until discharge from the postanesthesia care unit. Patients also were asked about knee pain before discharge from the postanesthesia care unit. Treatment, if required, for adverse effects or pain was recorded. In-hospital data collection ended once patients met discharge criteria from the postanesthesia care unit to the same day surgery ward.

Although resources to gather reliable data in the same day surgery unit were not available, the author, blinded to the anesthetic administered, completed a telephone interview of each participant 24 to 36 hours after hospital discharge. Patients were again asked about adverse effects, including urinary retention, nausea, and itching. They had been asked to record the time at which they had knee pain requiring treatment with analgesics. Unless contraindicated, postoperative pain was treated with oral hydrocodone and acetaminophen according to surgical protocol.

Data were analyzed with the assistance of computer software by Stata (Stata Corporation, College Station, Tex) using 1-tailed $t$ tests to determine differences in onset and duration of sensory and motor blocks and postoperative analgesia. The Fisher exact test was used to determine differences in patient demographics and adverse effects. $P$ values less than .05 were considered statistically significant. Data are presented as mean, standard deviation, range, and percentages.

**Results**

There were no differences in patient characteristics as measured by the Fisher exact test ($P > .05$; Table 1). The onset of sensory and motor block was not different between groups ($P > .05$; Table 2). The highest sensory levels achieved were T2 (C3 to T5) for group 1 and T3 (C8 to T6) for group 2, which were not significantly different. There was no significant difference ($P > .05$) in time of regression from highest level to T10 in group 1 (137 ± 34 minutes) compared with group 2 (123 ± 40 minutes; Table 3). Similarly, there was no difference in time for resolution of the motor block to Bromage class 0 between group 1 (155 ± 48 minutes) and group 2 (151 ± 40 minutes; $P > .05$; Table 3).

There were no significant differences in the number of patients experiencing respiratory depression, bradycardia, hypotension, a high sensory

<table>
<thead>
<tr>
<th>Table 1. Patient characteristics*</th>
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<tbody>
<tr>
<td>Group 1 (n = 27)</td>
</tr>
<tr>
<td>Age (y)</td>
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<tr>
<td>Weight (kg)</td>
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<tr>
<td>Height (in)</td>
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*Values are expressed as mean ± SD. Group 1 received fentanyl and group 2, saline.

<table>
<thead>
<tr>
<th>Table 2. Onset of sensory and motor block following injection*</th>
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<tbody>
<tr>
<td>Sensory level</td>
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<tr>
<td>Group 1</td>
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<tr>
<td>+ 2 min</td>
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<tr>
<td>+ 4 min</td>
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<tr>
<td>+ 6 min</td>
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<tr>
<td>+ 8 min</td>
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<td>+ 10 min</td>
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*Sensory levels are expressed as mean and range described by dermatomal level. Motor block was determined and expressed as mean Bromage class. Group 1 received fentanyl and group 2, saline.

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<th>Table 3. Duration of sensory and motor block*</th>
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<tr>
<td>Group 1</td>
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<tr>
<td>Peak sensory level*</td>
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<tr>
<td>Resolution to T10 (min)</td>
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<tr>
<td>Resolution to Bromage 0 (min)</td>
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*Values are expressed as mean ± SD. Group 1 received fentanyl and group 2, saline.
†Peak sensory levels are described as mean and range of dermatome levels.
Table 4. Incidence of adverse effects*

<table>
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<tr>
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<th>Group 1 OR PACU</th>
<th>Group 2 OR PACU</th>
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<tr>
<td>Respiratory depression (RR, &lt;10)</td>
<td>1 1</td>
<td>0 0</td>
</tr>
<tr>
<td>Hypotension (MAP 20% less than baseline)</td>
<td>6 3</td>
<td>4 0</td>
</tr>
<tr>
<td>Bradycardia (HR 20% less than baseline)</td>
<td>5 5</td>
<td>4 3</td>
</tr>
<tr>
<td>Nausea</td>
<td>1 1</td>
<td>0 0</td>
</tr>
<tr>
<td>Pruritus</td>
<td>9\textsuperscript{t} 13\textsuperscript{t}</td>
<td>0 0</td>
</tr>
<tr>
<td>High block (T1)</td>
<td>2 0</td>
<td>1 0</td>
</tr>
<tr>
<td>Urinary retention</td>
<td>4\textsuperscript{t}</td>
<td>3\textsuperscript{t}</td>
</tr>
</tbody>
</table>

*Values are expressed as number of patients. Group 1 received fentanyl and group 2, saline. OR indicates operating room; PACU, postanesthesia care unit; RR, respiratory rate; MAP, mean arterial pressure; and HR, heart rate.
\textsuperscript{t}Significant (P < .05), fentanyl vs saline in the OR and fentanyl vs saline in the PACU.
\textsuperscript{t}Assessed postoperatively.

The incidence of pruritus was significantly higher for group 1 compared with group 2 in the operating room (33% vs 0%) and the postanesthesia care unit (48% vs 0%; Table 4). Three of the patients experienced itching that was treated with 5 to 10 mg of intravenous nalbuphine. The decision to treat this and all adverse effects was left to the staff anesthesia provider and is reported anecdotally. One patient (4%) in group 1 requested pain medication before discharge from the hospital, while 5 (22%) of the patients in group 2 requested treatment for pain (Figure 1). Postoperative telephone interviews revealed that patients in group 1 took oral pain medication on average 10.3 ± 3.3 hours after intrathecal injection compared with 7.0 ± 3.7 hours for group 2, a significant difference (Table 5). During the telephone interview 24 to 36 hours later, patients were asked specifically about adverse effects known to accompany spinal anesthesia and intrathecal narcotics. Specifically, they were queried about nausea, itching, difficulty urinating, back pain, and overall comfort with the procedure. It is important to note that patients' discomfort with pruritus may be substantial enough that patients would not choose spinal anesthesia in the future if the same amount of itching is anticipated. This, in fact, was a concern related by 2 of the 13 patients experiencing pruritus in group 1.

Discussion

Fentanyl, 25 µg intrathecally, did not prolong sensory or motor block when combined with spinal bupivacaine, 12 mg, for outpatient knee arthroscopy. Patients in group 1 did not require analgesics for a mean time of 3.3 hours longer than patients in group 2. This finding is in agreement with those of previous studies that demonstrate that intrathecal fentanyl effectively prolongs postoperative analgesia.\textsuperscript{1,11,12,18,19} Of all patients, 6 (12%) received treatment for pain before leaving the hospital; 5 times as many patients in group 2 received treatment as patients in group 1. The increased duration of postoperative analgesia with intrathecal fentanyl was statistically significant (P > 0.05) (Figure 2).

There were no significant differences in respiratory depression, hypotension, nausea, high spinal block, or urinary retention in the 2 groups. Furthermore, there was almost no difference in level of anesthesia achieved in the 2 groups. The mean level achieved in group 1 was T2, and the

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**Table 5. Duration of postoperative analgesia**

<table>
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<tr>
<th>Patients requiring pain medication before discharge</th>
<th>Group 1</th>
<th>Group 2</th>
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<tbody>
<tr>
<td>Time before taking pain medication (min)\textsuperscript{t}</td>
<td>617 ± 196</td>
<td>418 ± 222</td>
</tr>
</tbody>
</table>

\textsuperscript{t}Duration of time is expressed as mean ± SD. Group 1 received fentanyl and group 2, saline.
Figure 2. Duration of postoperative pain relief

![Graph showing duration of postoperative pain relief](image)

mean level in group 2 was T3. Pruritus is a well-known adverse effect of neuraxial narcotics. A significant number (48%) of patients receiving fentanyl experienced itching. Three patients received treatment with nalbuphine, a mu receptor agonist-antagonist commonly used to reverse untoward effects of narcotics, such as pruritus or sedation. A 2-sample rank sum test was performed to determine if nalbuphine had an effect on duration of postoperative analgesia. There was no evidence that the nalbuphine-treated patients in group 2 had a decreased or prolonged duration of analgesia compared with patients in group 1 who had not received nalbuphine ($P > .05$).

Two episodes of nausea occurred in group 1. One was treated with 4 mg of ondansetron in the operating room and the other with 0.625 mg of droperidol in the postanesthesia care unit. The patient who experienced nausea in the operating room also demonstrated a substantially high block (C3) and hypotension. The adverse effects experienced by this patient included respiratory depression and bradycardia, which likely were caused by cerebral ischemia secondary to decreased venous return. The acute hypotensive episode responded well to a fluid bolus, ephedrine, and phenylephrine, which also resolved the other adverse effects.

In our study, hypotension in either group generally required no treatment or was treated without difficulty. Overall, 7 patients (14%) experienced urinary retention, 4 in group 1 and 3 in group 2. One patient in each group stated that discharge from the same day surgery unit was delayed because of urinary retention. The incidence of urinary retention was not statistically different between the 2 groups.

Patients in the present study experienced sensory anesthesia 5 levels higher despite lower doses of bupivacaine (12 mg) compared with the findings of a previous study using 13.5 mg. There are 2 possible explanations for this difference. One reason may be the methods of assessment. In the study by Singh et al, levels were assessed using a forcepts pinch in the midaxillary line. Sensory levels in the present study were assessed using temperature sensation with alcohol-soaked gauze. This test is an atraumatic sensitive indicator of sensory block and often produces less variability in patient response compared with a pinprick or a scratch. A cold stimulus may produce an assessment of sympathetic blockade conducted by the smaller myelinated B-fibers that generally are assessed approximately 2 segments higher than A-delta or C-fibers.

The second reason may be the mean age of patients in each study. In geriatric patients, bupivacaine produced a slightly greater block height compared with that produced in younger patients. For example, patients in their twenties receiving a given volume of isobaric bupivacaine 0.5% demonstrated a T9 level compared with a T6 level for patients in their eighties. By randomizing, we considered the effects of aging to be negligible on our overall results. To maintain generalizability, patients up to 65 years of age were permitted to participate, but the mean age of patients in the present study was in the sixties, while that for the sample in the study by Singh et al was in the sixties. Positioning of patients seemed to be the same in the 2 studies.

Differences in volume, position, and baricity may have major effects on block height. Increased anesthetic solution volume tends to increase block height. Position of the patient and baricity interact to affect block height. For example, solutions that are relatively hypertonic tend to move higher and more unilaterally when a patient is in the side-lying position as compared to a patient in the sitting position following injection, especially when maintaining the position until the block becomes stable.

Randomization and equal volumes in the 2 groups minimized variability. All injections in the present study were performed or supervised by one of us (43 patients by JR, 7 by LH) to maintain consistency. The methods of Singh et al involved aspirating cerebrospinal fluid to inject an equal volume in both groups. We attempted to maintain equivalent cerebrospinal fluid volumes and similar injectant baricities by adding equal volumes of saline.
fentanyl or saline to the fixed bupivacaine solution.

Interrater reliability is a concern in a clinically based study such as the present study. Use of temperature sensation to determine dermatome level is subject to operator variability. One study used a nerve stimulator set at different frequencies to determine responses to pain following epidural or intravenous fentanyl. Although the assessment of pain produced by a nerve stimulator may be difficult to reproduce because of patient perception and variations in power output, resistance, and other qualities of the device, this electrical stimulus may be useful to simulate surgical pain. This technique may reduce variability compared with the actual surgery because of variables such as length of surgery and the amount of surgical trauma. Furthermore, a consistent location of nerve stimulus may reduce variability in dermatomal assessment. Dermatomes have several centimeters of width and tend to be subjective assessments of nerve conduction. A “high T10” versus a “low T9” can be assessed differently depending on the observer. Furthermore, 15 minutes between assessments may be too long to obtain accurate measurements. Two assessments of a low T9 prolong the block to T10 by 30 minutes, which can be significant. If the same observer performs the assessment the same way for all patients, this can be minimized. However, when different evaluators perform the assessment, the margin of error increases proportionally. Nevertheless, consistency in the assessment of dermatomes was accomplished in the present study by using the same dermatome model for each patient assessment. More studies could be done simulating surgical conditions more precisely and with better control of time, level of blockade, and assessment techniques to determine if fentanyl prolongs conditions that are suitable for surgery (eg, enhanced sensory and motor block and analgesia).

Based on the findings of the present study, fentanyl does not seem to provide these conditions. We found no difference in onset, duration, or resolution of sensory or motor block when adding 25 μg of fentanyl to 12 mg of hyperbaric bupivacaine for knee arthroscopy. The addition of fentanyl prolonged postoperative analgesia significantly. Only 1 patient in group 1 required treatment for pain before discharge, while 5 patients in group 2 required treatment. Although the discharge times were not compared, patients who require additional analgesics in the same-day surgery unit may experience unpleasant adverse effects, such as nausea and sedation, that could delay discharge. More studies to examine the effects on discharge times and cost comparisons also would be useful. Intrathecal fentanyl seem to be useful for outpatient knee arthroscopies. It is inexpensive and easy to add to the spinal anesthetic solution. Although there is a wide range for duration of analgesia, it seems that fentanyl results in a substantial reduction in immediate postoperative pain, which may improve patient satisfaction and reduce the need for additional analgesics before patient discharge. Pruritus, which may be bothersome enough to warrant treatment, was the only apparent disadvantage of fentanyl found in the present study.

REFERENCES


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CDR Louis Heindel, CRNA, ND, NC, USN, is the deputy director of the Navy Nurse Corps Anesthesia Program in Bethesda, Md.

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The opinions or assertions contained herein are the views of the authors and are not to be construed as official or as reflecting the views of the Department of the Navy, the Department of Defense, or the United States Government.

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(22) Pitkanen M, Haafpaniemi I., luominen M, Rosenberg E.
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<table>
<thead>
<tr>
<th>Emergence / min.</th>
<th>desflurane</th>
<th>sevoflurane</th>
<th>isoflurane</th>
<th>propofol</th>
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<tr>
<td>5.6</td>
<td>11.9</td>
<td>11.5</td>
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<td>4.8</td>
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**Faster discharge from PACU**

Faster discharge from PACU can improve efficiency and reduce costs

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Safety Information

Desflurane is not recommended for induction of general anesthesia in infants and children because of the high incidence of moderate-to-severe laryngospasm, coughing, breathholding, secretions, and oxyhemoglobin desaturation. However, induction in children may be accomplished by the administration of an intravenous induction agent or other volatile anesthetic followed by desflurane for maintenance.

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Suprane® (desflurane, USP)

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Suprane® (desflurane, USP) is used for short-term induction of anesthesia in combination with mask inhalation or as a vaporizer for maintenance of anesthesia. It is also used for emergence and maintenance of anesthesia when added to anesthetic agents or when used alone in regional anesthesia techniques.

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Suprane® (desflurane, USP) should not be used in patients with a known or suspected sensitivity to desflurane, its excipients, or any anesthetic agent.

Precautions

Conduction block, hypotension, and bradycardia associated with the administration of desflurane have been observed. The effects of desflurane on cardiovascular function are similar to those of other inhalational anesthetics. Patients with a history of cardiovascular disease or those at increased risk of cardiovascular events during general anesthesia should be monitored closely. Patients with a history of hypertension, congestive heart failure, or other cardiovascular disease should be observed for any signs of hypotension or bradycardia.

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Suprane® (desflurane, USP) is not recommended for induction of general anesthesia in infants or children because of the high incidence of moderate to severe laryngospasm in 50% of patients. The effect of desflurane on the respiratory system is dose-dependent.

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The safety of desflurane during labor or delivery has not been demonstrated.

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The effects of desflurane on cardiovascular function are similar to those of other inhalational anesthetics. Patients with a history of cardiovascular disease or those at increased risk of cardiovascular events during general anesthesia should be monitored closely. Patients with a history of hypertension, congestive heart failure, or other cardiovascular disease should be observed for any signs of hypotension or bradycardia.

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Overdosage

In cases of overdose or suspected overdose, take the following actions: discontinue administration of Suprane® (desflurane, USP), maintain a patent airway, enforce assisted or controlled ventilation with oxygen, and maintain adequate cardiovascular function.

Suprane® is supplied as either an anesthetic vaporizer or as a canister for use with a vaporizer specifically designed and designated for use with desflurane.

Eight patients recevuing Suprane® (desflurane, USP) were compared to six patients receiving isoflurane, all with chronic obstructive pulmonary disease (COPD), valvular heart disease, renal insufficiency, or malignancy. No differences were found in a comparison of patients receiving Suprane® (desflurane, USP) and propofol, desflurane, or isoflurane under similar conditions.

References

Clinically Proven to:
- Reduce hypnotic drug use
- Allow faster and more consistent wake-up and recovery
- Significantly increase eligibility for Phase-1 PACU bypass
- Improve quality of post-anesthesia recovery
- Assess risk of awareness

For more information or to arrange a demonstration:
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