

Recovery Profiles and Costs of Anesthesia for Outpatient Unilateral Inguinal Herniorrhaphy

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The use of an ilioinguinal-hypogastric nerve block (IHNB) as part of a monitored anesthesia care (MAC) technique has been associated with a rapid recovery profile for outpatients undergoing inguinal herniorrhaphy procedures. This study was designed to compare the cost-effectiveness of an IHNB-MAC technique with standardized general and spinal anesthetics techniques for inguinal herniorrhaphy in the ambulatory setting. We randomly assigned 81 consenting outpatients to receive IHNB-MAC, general anesthesia, or spinal anesthesia. We evaluated recovery times, 24-h postoperative side effects and associated incremental costs. Compared with general and spinal anesthesia, patients

receiving IHNB-MAC had the shortest time-to-home readiness (133 ± 68 min vs 171 ± 40 and 280 ± 83 min), lowest pain score at discharge (15 ± 14 mm vs 39 ± 28 and 34 ± 32 mm), and highest satisfaction at 24-h follow-up (75% vs 36% and 64%). The total anesthetic costs were also the least in the IHNB-MAC group ($\$132.73 \pm 33.80$ vs $\$172.67 \pm 29.82$ and $\$164.97 \pm 31.03$). We concluded that IHNB-MAC is the most cost-effective anesthetic technique for outpatients undergoing unilateral inguinal herniorrhaphy with respect to speed of recovery, patient comfort, and associated incremental costs.

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Local anesthesia with IV sedation (so-called monitored anesthesia care [MAC]), spinal (subarachnoid) anesthesia, and general anesthesia are all commonly used anesthetic techniques for outpatients undergoing inguinal herniorrhaphy procedures (1–8). In the current cost-conscious environment, it is important to examine the impact of anesthetic techniques on the recovery process after ambulatory surgery because prolonged recovery times and perioperative complications increase the cost of patient care. In addition, patient satisfaction is improved when the anesthetic technique chosen for the procedure is associated with a small incidence of postoperative side effects. The ilioinguinal-hypogastric nerve block (IHNB) also decreases postoperative pain after MAC in outpatients undergoing inguinal hernia repair procedures (1,2).

We hypothesized that the technique of MAC with an IHNB and propofol sedation would be superior to both general and spinal anesthetic techniques with respect to its recovery and side effects profile. Therefore, this study was designed to evaluate the recovery times, side effects, patient satisfaction, and associated anesthetic-related institutional costs with three standardized anesthetic techniques in outpatients undergoing unilateral inguinal herniorrhaphy procedures.

Methods

After obtaining institutional review board approval, 81 consenting ASA physical status I and II outpatients, ages 18–65 yrs, scheduled for a unilateral inguinal hernia repair procedure were enrolled in this clinical study. Patients with known cardiovascular, respiratory, renal/hepatic, or metabolic disease, active gastrointestinal reflux, as well as those with mental dysfunction, morbid obesity, or history of substance abuse, were excluded from the study. Patients were randomly assigned, according to a computer-generated, random-number table, to receive one of the following three anesthetic techniques: Group 1, a MAC technique consisting of an IHNB and propofol sedation; Group 2, general anesthesia with laryngeal

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mask airway; or Group 3, spinal anesthesia with a hyperbaric bupivacaine-fentanyl solution.

All patients were premedicated with 2 mg of IV midazolam and 25 μg IV fentanyl. In Group 1, patients received an IHNB with a 30 mL of mixture containing 0.25% bupivacaine and 1% lidocaine injected through the oblique muscles approximately 1.5 cm medial to the anterior superior iliac spine. A 75 $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ IV propofol infusion, was started after the IHNB and subsequently varied between 25 and 150 $\mu\text{g} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ to maintain a level of sedation at which the patient readily responded to verbal or light tactile stimulation. Surgery was initiated approximately 8–10 min after the IHNB was completed. In Group 2, anesthesia was induced with 2.5 mg/kg IV propofol, and a laryngeal mask airway was placed for airway management. Anesthesia was initially maintained with 1% inspired sevoflurane in combination with 65% nitrous oxide in oxygen, and the inspired sevoflurane was varied between 0.5% and 2% with the patient breathing spontaneously. In Group 3, patients were administered spinal anesthesia using the midline approach with a 25-gauge pencil-point needle at the L2-3 or L3-4 intervertebral space with the patient in the sitting position. The subarachnoid injection contained a mixture of 1.2–1.5 mL of 0.75% bupivacaine and 25 μg of fentanyl.

Prior to skin incision and during surgery, the operative site (and genital-femoral nerve) was infiltrated with 10 mL of the solution containing 0.25% bupivacaine and 1% lidocaine in all three groups. The protocol also allowed the anesthesia provider to administer 25–50 μg IV boluses of fentanyl and 10–20 mg IV boluses of propofol to treat pain and purposeful movements, respectively, during the operation in all three groups. Patients in Groups 1 and 3 who failed to achieve adequate surgical or anesthetic conditions were converted to general anesthesia with propofol and sevoflurane/nitrous oxide.

Recovery times were recorded from the end of surgery to awakening (opening eyes on verbal command), orientation (correctly stating the date, place, and person) and home readiness (meeting the criteria for discharge home from the day surgery unit). Before leaving the operating room (OR), all patients were evaluated for fast-track eligibility (score >12) by the attending anesthesiologist (9). Those who achieved fast-track eligibility prior to leaving the OR were taken directly to the Phase 2 recovery area, bypassing the postanesthesia care unit (PACU). A 100-mm visual analog scale (VAS), with 0 = none to 100 = most severe, was used to assess pain and nausea prior to anesthesia administration (baseline), on arrival at the recovery area, and subsequently at 30 min intervals until discharge. Home readiness was assessed at 15 min intervals in the Phase 2 recovery unit by a blinded observer. At 24-h postoperatively, adverse events were assessed by a blinded investigator (DS)

Table 1. Basic Cost Assumptions for the Economic Analysis

| | Cost (USD) |
|--|------------|
| Anesthetic equipment costs | |
| Anesthetic circuit, suction | 7.58 |
| Laryngeal mask airway (cleaning, sterilizing, 50 uses) | 7.75 |
| Infusion pump tubing and disposable | 1.68 |
| Spinal tray, gloves, needle, lidocaine | 10.54 |
| Salter cannulae | 2.55 |
| Anesthetic drug costs | |
| 200 mg propofol | 15.00 |
| 100 μg fentanyl | 1.89 |
| Sevoflurane 250 mL | 189.00 |
| Lidocaine 2% (20 mL) | 0.60 |
| Bupivacaine 0.5% (30 mL) | 2.92 |
| Recovery room drug costs | |
| Droperidol | 0.19 |
| 4 mg ondansetron | 16.35 |
| Hydrocodone/acetaminophen | 0.50 |
| 25 mg meperidine | 0.66 |
| Recovery room resources costs | |
| Emesis management (per episode) | 2.50 |
| Oxygen delivery equipment | 0.66 |
| Nursing labor costs (hourly) | 22.00 |
| Operating room costs (hourly—two nurses, one aide) | 55.00 |

USD = United States dollars.

using a standardized postoperative telephone interview. Patient satisfaction with the anesthetic technique was evaluated using a three-point scoring system of 1 = poor, 2 = good, or 3 = excellent.

An *a priori* power analysis based on previously published data, suggested that a minimum of 25 patients in each group would be required to detect a 30% reduction in total institutional costs, with a power of 90% at the 0.05 level of significance. This group size would also be adequate to detect a 30% difference in VAS scores for pain and nausea with a power of 0.8 ($\alpha = 0.05$). Data analysis was on an "intent-to-treat" basis, where data from patients who required general anesthesia when the local/sedation or spinal anesthetic technique failed were included in the original assignment group. Continuous data were analyzed using one-way analysis of variance and if significant differences were noted, a Student-Neuman-Kuels test was used for intergroup comparisons. Categorical data were analyzed using the χ^2 test with Yates' continuity correction or Fisher's exact test, where appropriate, with $P < 0.05$ considered statistically significant.

The perspective used in the cost analysis was that of the chief financial officer of the ambulatory surgical center. The marginal costs of drugs and resources (Table 1) were calculated based on the actual acquisition costs to the center and not based on patient charges. These included the costs of anesthetic drugs administered in the OR and analgesic and antiemetic drugs administered in the recovery area. Drugs and resources common to all

Table 2. Patient Demographic Characteristics, Anesthesia, Surgery, and Recovery Times for Ilioinguinal Hypogastric Nerve Block-Monitored Anesthesia Care (IHNB-MAC), General Anesthesia, or Spinal Anesthesia for Inguinal Herniorrhaphy Procedures^a

| | IHNB-MAC (Group 1) | General anesthesia (Group 2) | Spinal anesthesia (Group 3) |
|---|-----------------------|---------------------------------|--------------------------------|
| Number (<i>n</i>) | 28 | 28 | 25 |
| Age (yr) | 42 ± 18 | 36 ± 16 | 39 ± 14 |
| Weight (kg) | 73 ± 9 | 75 ± 10 | 73 ± 14 |
| Height (cm) | 177 ± 8 | 171 ± 14 | 169 ± 8 |
| Sex (M/F) | 26/2 | 24/4 | 20/5 |
| ASA physical status (I/II) (<i>n</i>) | 16/12 | 20/8 | 11/14 |
| Time of anesthesia (min) | 109 ± 23 | 119 ± 29 | 116 ± 24 |
| Time of surgery (min) | 86 ± 21 | 93 ± 31 | 91 ± 22 |
| Intraoperative MAP (mm Hg) | 79 ± 9 | 72 ± 11 | 74 ± 8 |
| Intraoperative HR (bpm) | 67 ± 8 | 67 ± 9 | 62 ± 8 |
| Intraoperative RR (bpm) | 15 ± 3 | 13 ± 3 | 14 ± 3 |
| ETCO ₂ (mm Hg) | 39 ± 5 | 44 ± 9 | 37 ± 4 |
| Propofol (mg) | 312 ± 192 | 166 ± 41* | 84 ± 44*† |
| Fentanyl (μg) | 94 ± 44 | 125 ± 76 | 66 ± 49 ^b |
| IV Fluids (mL) | 1230 ± 354 | 1189 ± 422 | 1112 ± 286 |
| Recovery times (min) ^b | | | |
| Awakening | 3 ± 2 | 5 ± 2* | 0 ± 1*† |
| Orientation | 5 ± 4 | 11 ± 5* | 1 ± 2*† |
| Phase 1 PACU (min) | 5 ± 14 | 40 ± 13* | 35 ± 22* |
| Phase 2 unit (min) | 153 ± 67 | 168 ± 58 | 276 ± 86*† |
| Home-readiness (min) | 133 ± 68 | 171 ± 40* | 280 ± 80*† |
| Actual discharge (min) | 158 ± 71 | 208 ± 56* | 309 ± 83*† |

^a Values are mean ± SD and numbers.^b Following discontinuation of the anesthetic.

HR = heart rate, MAP = mean arterial pressure, RR = respiratory rate, PACU = postanesthesia care unit.

* *P* < 0.05 versus IHNB-MAC group.† *P* < 0.05 versus general anesthesia group.

three groups (electrocardiogram leads, pulse oximeter probes, IV catheters, and administration sets, etc) were not included, but the cost of wasted drugs was included. The cost of sevoflurane was calculated using the formula (10): cost = (delivered concentration × fresh gas flow × time × molecular weight × cost of 1 mL)/(2412 × density of sevoflurane).

The cost of resources used in the recovery areas for managing and treating postoperative pain and nausea was included in the total costs. Nursing labor costs were based on the actual time spent by the nurse with a patient and prorated for the number of patients cared for at that time. For patients in the PACU, the nurse/patient ratio was 1:2 and in the Phase 2 recovery area it was 1:5, in keeping with the recommendations of the American Association of PACU Nurses. The total costs of each anesthetic technique were calculated by summing the costs of drugs, nursing labor, and resources used.

Results

There were no statistically significant differences among the three anesthetic treatment groups with respect to demographic characteristics, duration of anesthesia and surgery, and intraoperative mean arterial

pressure, heart rate, respiratory rate, end-expiratory carbon dioxide values, as well as the amount of IV fluid administered during the operation (Table 2). Operating conditions and analgesia were unsatisfactory in two patients in Group 1 and one patient in Group 3. These three patients required general anesthesia for completion of the operation. The total dosage of propofol used during surgery was largest in Group 1 and significantly different from the other two groups (Table 2). Intraoperative fentanyl requirements were significantly larger in Group 2 compared with Group 3 (Table 2).

Patients in Groups 1 and 3 had faster awakening and orientation times than patients in Group 2. With the exception of the two patients who required "rescue" general anesthesia, all patients in Group 1 were transferred directly from the OR to the Phase 2 recovery area. In Group 3, 16% of the patients were judged to be fast-track eligible and were taken directly to the Phase 2 recovery unit. The time-to-home readiness (Table 2) and the maximum postoperative pain score (Table 3) were significantly decreased in Group 1 compared with the other two groups. However, the percentages of patients taking oral pain medication after discharge home were similar with all three techniques

Table 3. Anesthetic-Related Side Effects and Patient Satisfaction in the Ilioinguinal Hypogastric Nerve Block-Monitored Anesthesia Care (IHNB-MAC), General Anesthesia, or Spinal Anesthesia for Inguinal Herniorrhaphy Procedures^a

| | IHNB-MAC (Group 1) | General anesthesia (Group 2) | Spinal anesthesia (Group 3) |
|--|-----------------------|------------------------------------|-----------------------------------|
| Postoperative side effects (n[%]) | | | |
| Backache | 0 | 0 | 6 (24)*† |
| Drowsiness | 4 (14) | 15 (54)* | 3 (12)† |
| Headache | 2 (7) | 4 (14) | 3 (12) |
| Knee weakness | 3 (11) | 1 (4) | 3 (12) |
| Muscle aches | 0 | 2 (7) | 0 |
| Nausea and/or vomiting | 2 (7) | 17 (61)* | 3 (12)† |
| Pruritus | 0 | 0 | 6 (24)*† |
| Sore throat | 0 | 6 (22)* | 2 (8)† |
| Urine retention | 0 | 0 | 5 (20)*† |
| Maximum nausea VAS (mm) | 1 ± 5 | 27 ± 27* | 4 ± 1† |
| Maximum pain VAS (mm) | 15 ± 14 | 39 ± 28* | 34 ± 32* |
| Oral analgesia after discharge (n[%]) | 16 (57) | 18 (64) | 17 (68) |
| Satisfaction with anesthetic technique | | | |
| Poor | 0 | 0 | 0 |
| Good | 7 (25) | 18 (64)* | 9 (36) |
| Excellent | 21 (75) | 10 (36)* | 16 (64) |

^a Values are mean ± SD, numbers (n), and percentages (%).

* *P* < 0.05 versus IHNB-MAC group.

† *P* < 0.05 versus general anesthesia group.

(Table 3). All general anesthesia patients initially recovered in the PACU.

The incidence of side effects, namely sore throat, drowsiness, and postoperative nausea and vomiting (PONV), as well as the maximum VAS nausea scores, were significantly higher in the general anesthesia group (Table 3). Patients receiving spinal anesthesia had the highest incidence of postoperative pruritus, urinary retention, lumbar backache (Table 3), and the longest time to achieve home discharge criteria (Table 2).

Finally, patient satisfaction with anesthesia is summarized in Table 3. None of the study patients reported a score of "poor." However, compared with the general anesthetic technique, the use of IHNB-MAC was associated with significantly higher patient satisfaction scores.

The cost of drugs used during the intraoperative period differed significantly in the three groups, with the lowest cost in Group 3 and highest in Group 2 (Table 4). The cost of anesthetic supplies was lowest in Group 1. Labor cost did not differ among the three

groups during the intraoperative period, but was significantly lower in Group 1 during the postoperative period. The combined cost of drugs and supplies used in the postoperative period was significantly higher in the general anesthesia group compared with the other two groups. The total perioperative cost was significantly lower in the IHNB-MAC group compared with the other two groups, but did not differ between the general and spinal anesthesia groups.

Discussion

This study demonstrates that the use of an IHNB with propofol sedation for inguinal herniorrhaphy provides significant advantages over both general and spinal anesthesia. Patients receiving an IHNB-MAC technique had a shorter time-to-home readiness and lower pain scores at discharge. This technique was also associated with the lowest overall cost and highest patient satisfaction scores. In other studies, the use of a MAC technique for inguinal hernia repair has been found to have the additional advantages of early postoperative mobilization (4,5,7,11,12) and decreased incidences of urinary retention (4,6,13,14), nausea, vomiting, and sore throat (2,5,6). Furthermore, the ability to test the integrity of the repair during the operation (3-6,13) with a MAC anesthetic is another advantage compared with spinal or general anesthesia.

The combination of high patient satisfaction, low cost, and early discharge suggests that the highest quality (cost/outcome) anesthetic was achieved with the IHNB-MAC technique. Cost estimates of various anesthetic regimens are available, but many of these pharmacoeconomic studies have limited cost considerations to only the acquisition cost of the drugs; and not the total expenses associated with the technique used. The total cost should include both the acquisition cost of drugs and the labor required for managing side effects (PONV, pain, drowsiness, bladder dysfunction). Since nursing personnel costs constitute a major proportion of expenses in the OR and recovery areas, anesthetic techniques associated with a greater need for nursing services will be more expensive (15). This study included nursing labor costs in the total cost of an anesthetic regimen, using the cost accountant's standard concept of opportunity cost. This assumes that the time a nurse spends with one patient is time away from other activities that will then have to be performed by another salaried individual. However, it may be inappropriate to assume there is a linear relationship between labor cost and the time spent providing a clinical service (15).

There is a much clearer relationship between lower cost and bypassing of the Phase 1 recovery unit. The major labor cost in the PACU is related to the peak number of patients admitted to the unit at any given

Table 4. Incremental Costs in the Operating Room (OR) and the Postanesthesia Care Units Associated With Ilioinguinal Hypogastric Nerve Block-Monitored Anesthesia Care (IHNB-MAC), General Anesthesia, or Spinal Anesthesia for Inguinal Herniorrhaphy Procedures^a

| | IHNB-MAC (Group 1) | General anesthesia (Group 2) | Spinal anesthesia (Group 3) |
|-----------------------------|-----------------------|---------------------------------|--------------------------------|
| Intraoperative costs | | | |
| Drugs | 34.66 ± 17.47 | 42.62 ± 9.88* | 17.13 ± 10.42*† |
| Supplies | 5.22 ± 3.63 | 13.83 ± 1.12* | 13.84 ± 2.77* |
| OR non-labor | 39.88 ± 19.46 | 56.45 ± 9.88* | 30.97 ± 12.98*† |
| OR labor | 102.63 ± 19.46 | 109.87 ± 9.88 | 107.32 ± 22.17 |
| TOTAL COSTS | 142.51 ± 22.74 | 166.32 ± 26.91* | 138.30 ± 28.01*† |
| Recovery costs | | | |
| Drugs | 0.15 ± 0.31 | 8.82 ± 8.51* | 1.03 ± 3.23*† |
| Supplies | 0.05 ± 0.17 | 0.86 ± 0.68* | 0.73 ± 0.37*† |
| Nursing labor | | | |
| Phase 1 | 0.85 ± 2.57 | 7.11 ± 2.77* | 6.34 ± 4.10* |
| Phase 2 | 11.56 ± 5.21 | 13.10 ± 6.65* | 19.04 ± 10.12* |
| Total | 12.41 ± 6.68 | 20.21 ± 7.79* | 25.39 ± 10.31*† |
| TOTAL COSTS | 12.61 ± 6.84 | 29.88 ± 9.68* | 27.15 ± 11.14* |
| Perioperative costs | | | |
| Total drug cost | 34.81 ± 17.56 | 51.44 ± 14.80* | 18.16 ± 9.76*† |
| Total supplies | 5.27 ± 3.80 | 14.69 ± 0.68* | 14.58 ± 2.78* |
| Total resources used | 40.07 ± 19.67 | 66.12 ± 15.09* | 35.74 ± 12.39† |
| Total labor costs | 115.05 ± 26.67 | 130.08 ± 27.91* | 132.71 ± 23.89* |
| TOTAL COSTS | 132.73 ± 33.80 | 172.67 ± 29.82* | 164.97 ± 31.03* |

^a Values are mean ± SD (in US dollars).* *P* < 0.05 versus IHNB-MAC group.† *P* < 0.05 versus general anesthesia group.

time. Therefore, even if a patient spends an additional 15 to 30 minutes in the PACU, institutional costs may not be affected unless overtime cost is incurred. Fast tracking may also permit the use of fewer nurses and a mix of lower-wage nursing aides with registered nurses. With the exception of two patients who required a rescue with general anesthesia, all patients in the IHNB-MAC group met the PACU discharge criteria prior to leaving the OR and were able to "bypass the PACU," contributing to a shorter time to discharge home compared with general and spinal anesthesia groups. However, a criticism of the study is that all patients receiving general anesthesia were required to be admitted to the PACU. If nursing practices mandate a minimum stay in the various recovery areas, there may not be any financial benefit to an institution from the faster recovery profiles associated with the newer anesthetic drugs.

The time-to-home readiness is a clinical determination indicating completion of the early recovery process. Factors contributing to delays in the time-to-home readiness include drowsiness, nausea, vomiting, inability to void, postural hypotension, prolonged motor blockade, and administrative (and social) delays (1,6-8,11,12,16). The longer time-to-home readiness with spinal (versus general) anesthesia is probably related to the residual motor and sympathetic blockade. Even with an IHNB, ambulation can be delayed

by transient femoral nerve palsy when the local anesthetic solution is injected deep to the internal oblique muscle (17,18).

Inadequate pain control in the postoperative period can also contribute to prolonging the time-to-home readiness and increasing patient dissatisfaction (19-21). The patients in the IHNB-MAC group were found to have lower pain scores even though the patients in the spinal and general anesthesia groups also received local anesthesia at the incision site. Previous studies (2,3,6,8) have reported longer times-to-first analgesia after herniorrhaphy with the use of local infiltration, but these studies vary as to the technique of local anesthetic administration. Although patients receiving IHNB had lower discharge pain scores, their requirements for oral pain medications after discharge did not differ from the other two treatment groups.

Spinal anesthesia can provide for a profound conduction block and preemptive analgesia while minimizing complications associated with general anesthesia (PONV, sore throat) (6,8,22). However, the popularity of spinal anesthesia for outpatient surgery has been tempered by concerns regarding transient radicular irritation, urinary retention, and postdural puncture headache (14,23,24). Transient radicular irritation occurs in up to 5% of patients receiving lidocaine, but appears in <1% receiving bupivacaine (23).

Although 24% of patients in the spinal anesthesia group complained of mild lumbar discomfort postoperatively, there were no reports of radiating back discomfort. Unfortunately, the residual motor and sympathetic blockade with bupivacaine led to a prolonged recovery and delayed discharge.

General anesthesia remains the technique of choice for uncooperative or anxious patients, difficult repairs (reoperation after a mesh repair), and when a local anesthetic technique fails to provide adequate surgical conditions (4). In our study, two patients in the IHNB-MAC group and one in the spinal anesthesia group required conversion to general anesthesia for completion of the procedure. Data from these patients were included in their original group assignment and the analysis was performed on an intention-to-treat basis. The rationale for this decision was based on the fact that it was reasonable to expect increased costs and decreased patient satisfaction in these subjects, and we felt that the study should reflect the "real-world" situation where failure of local anesthetic-based MAC techniques does occur.

In conclusion, the use of IHNB with propofol sedation for outpatients undergoing inguinal herniorrhaphy resulted in a shorter time-to-home readiness, lower pain scores at discharge, greater patient satisfaction, and lower associated, incremental costs compared with general and spinal anesthesia. In situations where fast tracking can provide benefits for the patient and the health care system, this MAC technique would appear to offer advantages over both general and spinal anesthetic techniques for inguinal herniorrhaphy procedures.

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