

A Comparative Study of General Anesthesia, Intravenous Regional Anesthesia, and Axillary Block for Outpatient Hand Surgery: Clinical Outcome and Cost Analysis

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Regional anesthesia for outpatient hand surgery can result in shorter recovery times and faster hospital discharge after surgery (1,2). These attributes may reduce the demand on nursing time and hospital cost. Potential disadvantages are longer induction time and technique-related failure that might increase operating room time. Unlike previous retrospective reviews (1,2), the present study prospectively examined three anesthetic techniques, namely general anesthesia, IV regional anesthesia, and axillary brachial plexus block, with respect to clinical outcome, time efficiency, and hospital cost.

Materials and Methods

After IRB approval and informed consent, we prospectively studied 126 outpatients scheduled for elective hand surgery. Excluded procedures were carpal tunnel release and ganglion excision (both usually performed under regional anesthesia), procedures anticipated to exceed 90 min, and bilateral hand surgery.

The anesthetic techniques studied were general anesthesia (GA), IV regional anesthesia (IVRA), and axillary brachial plexus block (BPB). The choice of anesthesia in each case was determined primarily by the patient, not by their medical conditions. When a patient elected regional anesthesia, the choice of IVRA or BPB was determined according to the anesthesiologist's preference, not according to surgical type or duration.

GA was induced using propofol and fentanyl and maintained with isoflurane (end tidal up to 1.5%), nitrous oxide 60% in oxygen via a laryngeal mask. IVRA was performed using 0.5% lidocaine (35–45 mL). Axillary BPB was performed using transarterial approach with a 40–50 mL admixture of 3% chloroprocaine and 2% lidocaine with 1:200,000 epinephrine or 1.5% lidocaine with 1:200,000 epinephrine. Midazolam, fentanyl and propofol were administered as necessary in the IVRA and BPB groups for sedation. In our institution, BPB is routinely performed before entering the operating room (OR) in a monitored area with the assistance of a nurse.

After surgery, patients were admitted to the post-anesthesia care unit (PACU) for a minimum of 30 min and discharged from the PACU using the Aldrete discharge criteria (3) and from the Day Surgery Unit (DSU) using the Postanesthesia Discharge criteria (4). For BPB, patients were discharged from PACU when there was some evidence of recovery in sensation or movement in the upper extremity as assessed by PACU nursing staff.

Perioperative data, including the type of surgery, anesthetic failures, and the incidence of pain, nausea, and vomiting requiring treatment in the PACU and DSU, were recorded by two unblinded research assistants. Failure of IVRA or BPB was defined as the inability to provide surgical anesthesia despite supplemental local infiltration or peripheral nerve block, requiring the use of general anesthesia. Anesthetic induction time, surgical time, anesthesia time, PACU and DSU times, and the total hospital stay time (time from the start of anesthesia to actual hospital discharge) were recorded.

Cost data were obtained from the Finance Department, University Health Network, Ontario, Canada. In

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Canada, the cost per case represents the direct expense to the hospital (in Canadian dollars), not the expense to patients. In our institution, each surgical service is assigned a cost center for which actual expenditure is monitored. The total nursing labor cost is calculated based on nursing time spent, the hourly staff wage (benefit included), and nurse-to-patient ratio in the respective unit (2:1 in the operating room, 1:2 in the PACU, and 1:4 in DSU). It is important to note that the hourly nursing staff wage presented in this study represents the actual cost to the hospital per hour of patient care. This figure is more than the hospital nursing pay rate because the costs of nursing time for activities (e.g., OR turnover, preparation, and sick leave) are included.

Anesthetic drug cost was obtained from the pharmacy department (Table 1) and calculated using the assumption that residual drug remaining in a single-use ampule was to be discarded. The cost of isoflurane was estimated using the formula published by Dion (5). Not included was the cost of oxygen and nitrous oxide. Anesthetic supply cost derived primarily from the laryngeal mask airway and the breathing circuit. If GA was required to supplement regional anesthesia, the cost of GA drugs and airway management was added to the Regional Anesthetic group.

Data were analyzed with SPSS Version 9.0 software (SPSS Inc., Chicago, US). Time interval, costs, age, height, and weight were analyzed with one-way analysis of variance. Nonparametric data were analyzed with one-way nonparametric analysis of variance followed by multiple comparisons with the Mann-Whitney *U*-test. Categorical data were analyzed using χ^2 or Fisher's exact test as appropriate. Values were considered significantly different when $P < 0.05$.

Results

Of the 126 patients recruited, 39 received GA, 45 received IVRA, and 42 received BPB. There was no statistically significant differences among groups in patient demographics (Table 2), types of surgery (Table 2), or surgical time (Table 3).

GA was required in two patients in the IVRA group and three in the BPB group because of failure of the local anesthetic block. The failure of IVRA was attributed to intolerable tourniquet pain after 30–40 min. Duration of anesthesia was longest in the BPB group, mainly as a result of significantly longer induction time (28 ± 17 min, including 16 ± 9 min of procedure time) than both IVRA and GA (10 ± 5 min).

After surgery, significantly more patients in the GA group (85%) experienced pain requiring opioid analgesics than those in the IVRA (51%) or BPB (43%)

Table 1. Basic Cost Assumptions for the Cost Analysis

	Cost (Canadian \$)
Anesthetic drug costs	
Midazolam, 2 mg	1.39
Fentanyl, 100 ug	0.59
Propofol, 200 mg	8.82
Isoflurane, 100-mL bottle	45.74
Lidocaine, 0.5%, 40 mL for IVRA	0.79
Lidocaine, 2%, 20 mL for BPB	1.05
Lidocaine, 1%, 20 mL for BPB	1.05
Chloroprocaine 3%, 30 mL for BPB	10
Epinephrine 1:1000, 1 mL	0.48
Anesthetic equipment costs	
Laryngeal mask	15.82
Recovery unit drug costs	
Morphine 10 mg	0.17
Tylenol 300 μ g/codeine 30 mg	0.05
Dimenhydrinate (antiemetic)	0.33
Nursing cost	
Operating room	60
Phase I recovery (postanesthesia care unit)	51
Phase II recovery (Day Surgery Unit)	21

IVRA = intravenous regional anesthesia; BPB = brachial plexus block.

Table 2. Demographic, Type of Surgery and Intraoperative Medication Data for the General Anesthesia (GA), Intravenous Regional (IVRA) and Brachial Plexus Block (BPB) Groups

	GA (n = 39)	IVRA (n = 45)	BPB (n = 42)
Sex (M/F)	24/15	26/19	29/13
Age (yr)	39 \pm 14	39 \pm 15	41 \pm 17
Height (cm)	171 \pm 10	170 \pm 11	172 \pm 11
Weight (kg)	78 \pm 19	77 \pm 28	75 \pm 16
ASA physical status (I/II/III)	27/11/1	29/13/3	28/12/2
Type of surgery			
Tendon	6	16	11
Amputation	2	0	2
Fracture fixation	8	9	9
Arthrodesis	2	0	2
Hardware removal	4	5	3
Nerve repair	8	6	6
Miscellaneous	9	9	9
Fentanyl (μ g)	135 \pm 80	53 \pm 95*	44 \pm 54†
Propofol (mg)	221 \pm 105	29 \pm 97*	58 \pm 94†
Midazolam (mg)	1 \pm 1	2 \pm 2*	2 \pm 1†

Values are mean \pm SD.

Miscellaneous = wrist arthroscopy, compartment release, flap revision.

* $P < 0.05$ comparing IVRA versus GA; † $P < 0.05$ comparing BPB versus GA.

groups ($P < 0.05$). Furthermore, the incidence of nausea and vomiting requiring antiemetic medication was most frequent in the GA group (62% vs 18% for IVRA and 12% for BPB) ($P < 0.05$).

Postanesthesia recovery was most rapid in the IVRA group (Table 3). Time to discharge from the PACU, the

Table 3. Intraoperative and Postoperative Times and Costs Associated with the General Anesthesia (GA), Intravenous Regional (IVRA) and Brachial Plexus Block (BPB) Groups

	GA (n = 39)	IVRA (n = 45)	BPB (n = 42)
Intraoperative times			
Induction (min)	10 ± 3	10 ± 5*	28 ± 17†
Surgery (min)	59 ± 33	45 ± 26	53 ± 21
Total anesthesia time (min)	83 ± 29	72 ± 30*	106 ± 27†
Postoperative times			
PACU recovery (min)	70 ± 14	45 ± 21*‡	63 ± 32
DSU recovery (min)	86 ± 55	63 ± 34‡	77 ± 50
Total hospital time (min)	240 ± 75	180 ± 58*‡	244 ± 68
Intraoperative costs			
OR labor (\$)	167 ± 59	144 ± 60*	213 ± 55†
OR Drugs & supplies (\$)	37 ± 9	6 ± 9*‡	16 ± 9†
Postoperative costs			
PACU labor (\$)	59 ± 12	38 ± 18*‡	54 ± 27
PACU Drugs and supplies (\$)	4 ± 1	3 ± 1*‡	4 ± 2
DSU labor (\$)	30 ± 19	22 ± 12	27 ± 17
DSU Drugs and supplies (\$)	2 ± 1	2 ± 1	2 ± 1
Perioperative costs			
Total labor costs	257 ± 71	204 ± 68*‡	293 ± 60†
Total drug/supply costs	44 ± 9	10 ± 9*‡	22 ± 10
Total perioperative costs	300 ± 77	214 ± 74*‡	317 ± 65

Values are mean ± SD; \$ are in Canadian dollars.

Induction time = time from the start of induction (marked by placement of monitors and of iv cannula) to the end of induction. For general anesthesia, the end of induction was defined as the time at which airway intubation was completed; for IVRA, the time at which local anesthetic injection was complete; and, for BPB, the sum of two time intervals—the time of completion of local anesthetic injection for the axillary block and the nursing time required for patient monitoring before entry to the operating room (OR); PACU time = time in the PACU from admission to discharge; DSU time = time in the DSU from admission to discharge; Total hospital time = time from start of anesthesia to actual hospital discharge; OR labor cost = labor cost for 2 operating room nurses per patient.

* $P < 0.05$ comparing IVRA versus BPB; † $P < 0.05$ comparing BPB versus GA; ‡ $P < 0.05$ comparing IVRA versus GA.

DSU, and the hospital was significantly shorter in the IVRA than in the BPB and GA groups ($P < 0.05$). There were no unanticipated hospital admissions after surgery.

Overall, the intraoperative and postoperative costs to the hospital were least in the IVRA group, approximately \$86 (Canadian) and \$103 (Canadian) less per case than with GA and BPB, respectively, reflecting cost savings of approximately 30% in both cases (Table 3). In the operating room, IVRA was associated with short induction time and lower anesthetic drug and equipment costs. In the PACU and DSU, IVRA was associated with less demand on nursing time and lower drug and supply cost.

Discussion

Results of this prospective study demonstrate that regional anesthesia is associated with a more favorable patient recovery profile than GA. Nausea and vomiting were less and residual analgesia was longer lasting in the PACU and DSU. Of the two regional techniques studied, IVRA offered the greatest perioperative clinical benefits, with hospital discharge approximately 1 h earlier than GA. However, the IVRA technique can fail as a result of tourniquet pain. Strategies to preempt tourniquet pain include the addition of an opioid (6) or a nonsteroidal antiinflammatory drug (7) to local anesthetic.

BPB is also a popular regional technique for outpatient hand surgery. Although effective, these data confirm that BPB is associated with longer induction time (by approximately 18 min) than GA and IVRA. The key to overcoming this apparent disadvantage of the BPB technique is to perform the block in advance of the scheduled surgery (e.g., use time between cases) to optimize OR utilization.

To capture the benefits of regional anesthetic techniques with respect to shorter discharge times from the PACU and DSU, it is necessary to upgrade post-anesthesia recovery policy to allow fast-track recovery pathway (e.g., bypassing the PACU) (8–10). Without a change in the operational system, rapid hospital discharge will not occur, as was the case with BPB in this study. An anesthetic technique can influence hospital costs by its effect on the demand of nursing time and cost of anesthetic drugs (11,12). For example, the reduction of nursing time with IVRA was most significant in the recovery period resulting in nursing time and cost saving of 30% in comparison with the GA technique. Second, the cost of anesthetic drug and supply required for IVRA in the OR was substantially less than that for GA (84% less), consistent with Chilvers et al.'s finding (13). The impact of drug cost saving however was much less significant when compared with nursing labor cost.

This study has demonstrated the potential impact of anesthetic techniques on recovery time, but time savings may not represent true cost savings. In a study using computer simulation, Dexter and Tinker (14) showed that the advantage in using anesthetic drugs (e.g., propofol) in reducing the duration of PACU stay or elimination of nausea and vomiting is insufficient to result in a significant reduction in the peak number of patients in the PACU. The PACU costs depend predominantly on peak PACU patient census, not average daily census. Thus, although we have shown that IVRA resulted in reduction of PACU stay and decreased the incidence of nausea and vomiting in comparison with GA, it is uncertain whether these benefits will translate into any significant reduction in

peak PACU patient census and nursing cost. Nevertheless, reduction of adverse events in the PACU will decrease nursing workload (15).

One can speculate that real cost saving can be realized only if there is an actual reduction in the number of admissions to the PACU and, in turn, in the number of nursing staff in the PACU. Dexter et al. (16) speculated that the use of rapid emergence techniques with PACU bypassing might improve utilization of recovery room nursing staff. The advantage of a fast-tracking policy after ambulatory surgery is that by taking a patient from the OR directly to the Phase II step-down unit (or DSU), actual time savings can be achieved (10). On the basis of the incidence of postoperative pain and emesis requiring treatment of patients in the present study, we speculate that regional anesthesia in the form of IVRA or BPB is more likely to permit fast-tracking of outpatient hand surgery patients than general anesthesia, consistent with recent ambulatory studies by Song et al. (hernia) (11) and Li et al. (anorectal surgery) (12).

The limitations of this study include the fact that the selection of anesthetic technique was not randomized. To minimize selection bias, we have excluded from study long complicated surgical procedures and those that favored a particular anesthetic technique. Second, these results are derived from a single university hospital setting. We realize that hospitals are likely to vary in the time for performing BPB, PACU discharge policy, nursing salaries, staffing schedules, and ambulatory surgery caseload. Third, newer volatile anesthetics were not used in the GA group. Although sevoflurane and desflurane will likely provide more rapid anesthetic emergence than isoflurane, it is unlikely that postoperative pain will occur less often with these drugs. Finally, a fast-track recovery policy was not implemented during the study period and discharge time reported in the present study might have been longer than necessary in all three groups. However, we anticipate that patients receiving IVRA will rapidly achieve fast track criteria, and therefore the advantages of IVRA will remain clinically relevant.

In summary, patients undergoing regional anesthesia for outpatient hand surgery are less likely to require analgesic and antiemetic medication during the recovery period than are those receiving GA. Of the three anesthetic techniques studied, IVRA offers the most clinical advantages, namely reduced nursing

time demand in the PACU and DSU and expedited hospital discharge.

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