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A Comparison of Infraclavicular Nerve Block versus *General Anesthesia for Hand and Wrist Day-case Surgeries*

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Background: **General anesthesia (GA) and brachial plexus block have been used successfully for surgery on the upper extremities. Controversy exists as to which method is more suitable in outpatients undergoing hand and wrist surgery. The authors hypothesized that infraclavicular brachial plexus block (INB) performed with a short-acting local anesthetic would result in shorter time to discharge home as compared with "fast-track" GA.**

Methods: **After obtaining written informed consent, 52 patients (aged 18–65 yr, American Society of Anesthesiologists physical status I–III) were randomly assigned to receive either an INB or GA under standardized protocols (INB = 3% 2-chloroprocaine + HCO_3 + epinephrine 1:300,000, followed by propofol sedation; GA = 12.5 mg dolasetron, propofol induction, followed by laryngeal mask airway insertion and desflurane for maintenance; 0.25% bupivacaine for wound infiltration). At the conclusion of the procedure, nurses blinded to the study goals and the anesthetic technique used a modified Aldrete score to decide whether patients could bypass the postanesthesia care unit. Additional data were collected regarding time to postoperative pain, ambulation, home readiness, and incidence of adverse events.**

Results: **More patients in the INB group (79%) met the criteria to bypass the postanesthesia care unit compared with patients in the GA group (25%; $P < 0.001$). Compared with patients in the GA group, fewer patients in the INB group had pain (visual analog scale score > 3) on arrival to the postanesthesia care unit (3% *vs.* 43%; $P < 0.001$). None of the patients in the INB group requested treatment for pain while in the hospital, compared with 48% of patients in the GA group ($P < 0.001$). Patients in the INB group were able to ambulate earlier (82 ± 41 min) compared with those in the GA group (145 ± 70 min; $P < 0.001$). Time to home readiness and discharge times were shorter for patients in the INB group (100 ± 44 and 121 ± 37 min) compared with those in the GA group (203 ± 91 and 218 ± 93 min; $P < 0.001$). Adverse events (*e.g.*, nausea, vomiting, sore throat) occurred less frequently in patients undergoing INB as compared with those undergoing GA.**

Conclusion: **Infraclavicular brachial plexus block with a short-acting local anesthetic was associated with time-efficient anesthesia, faster recovery, fewer adverse events, better analgesia, and greater patient acceptance than GA followed by wound infiltration with a local anesthetic in outpatients undergoing hand and wrist surgery.**

SURGERY of the hand or wrist is a common procedure usually performed on an outpatient basis. Both general anesthesia (GA) and brachial plexus block have been used successfully for surgery of the upper extremities. It has been suggested that use of peripheral nerve blocks may have some potential benefits in the outpatient setting and result in a lower risk of nausea or vomiting, earlier ambulation, enhanced pain relief, and earlier discharge. However, to our knowledge, there have been no studies specifically comparing peripheral nerve blocks performed with short-acting local anesthetics to "fast-track" GA in outpatients undergoing hand and wrist surgery. We hypothesized that infraclavicular brachial plexus block performed with a short-acting local anesthetic would result in shorter time to discharge home as compared with "fast-track" GA.

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Materials and Methods

The study was approved by the Institutional Review Board of St. Luke's-Roosevelt Hospital Center (New York, New York). Eligible patients were those aged 18–65 yr (n = 52) with American Society of Anesthesiologists physical status I–III, scheduled to undergo outpatient hand or wrist surgery or both of at least 30 min in duration. After obtaining written informed consent, patients were randomly assigned to receive either infraclavicular brachial plexus block (INB) or "fast-track" GA under standardized protocols.

Before anesthesia, all patients had an infusion of lactated Ringer's started through an indwelling intravenous catheter. Patients were monitored during surgery and

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recovery according to standards/guidelines published by the American Society of Anesthesiologists.

Infraclavicular Nerve Block

At the discretion of the anesthesiologist, patients could receive midazolam (2–6 mg) and alfentanil (250–750 μg) by intravenous injection, in divided doses, before the INB.[1] The goal of premedication was to decrease patient anxiety and discomfort during block placement while maintaining meaningful contact with the patient during the peripheral nerve block procedure (patient easily arousable and responds appropriately to verbal commands). Supplemental oxygen (5 l/min) was administered by facemask throughout the procedure. INB was performed using a 22-gauge, 100-mm Stimuplex block needle (B. Braun Medical Inc., Bethlehem, PA) and a nerve stimulator (Tracer II; LifeTech Inc., Houston, TX).[2] Forty milliliters 2-chloroprocaine, 3% (alkalinized with 1 mEq bicarbonate/10 ml, containing 1:300,000 epinephrine), was injected after a motor response had been obtained with a current of 0.2–0.4 mA in the distribution of the medial cord of the brachial plexus (flexion of the hand or fingers). After injection, surgeons were allowed to proceed with surgical preparation without waiting to document full onset of surgical anesthesia. During the procedure, all patients received an intravenous infusion of propofol (Diprivan®; AstraZeneca Pharmaceuticals LP, Wilmington, DE). The goal of propofol administration was to have a lightly sleeping patient who could be easily aroused to answer questions, if needed. By protocol, no other intraoperative sedatives or opioids were allowed. Patients with inadequate surgical anesthesia upon incision and those who required supplementation with opioids were given GA using propofol for induction followed by placement of a laryngeal mask airway. These patients were excluded from the analysis. All INB procedures were performed by senior residents or regional anesthesia fellows under supervision of an attending anesthesiologist with substantial experience in regional anesthesia. At the conclusion of the procedure, after wound dressing or cast application, the propofol infusion was stopped and the patient was taken to phase 1 postanesthesia care unit (PACU).

General Anesthesia

Patients assigned to receive GA were given preoperative dolasetron (12.5 mg) by intravenous injection, midazolam (1–2 mg), and fentanyl (50–100 μg). After induction of GA with propofol (1.5–2.0 mg/kg), a laryngeal mask airway was inserted, and anesthesia was maintained with desflurane in a mixture of 50:50 nitrous oxide in oxygen. The concentration of desflurane was kept between 3% and 6% as monitored by mass spectrometry (Capnomac Ultima ULT1; Datex Ohmida, Helsinki, Finland). By design, fentanyl was the only opioid allowed intraoperatively, and its administration was left to the discretion of the anesthesia team caring for the patient. Muscle relaxants and reversal agents were not allowed. Surgeons were asked to begin surgical preparation of the limb as soon as the laryngeal mask airway was placed. At the end of the surgical procedure, the surgeon infiltrated the incision with 5–10 ml bupivacaine (0.25%). Patients were awakened from GA at the conclusion of the procedure after wound dressing, cast application, or both.

Recovery

At the conclusion of the procedure, patients were taken to phase 1 PACU, where nurses, unaware of the study and the anesthetic technique used, evaluated the patient using a modified Aldrete score (appendix 1) and made a decision regarding the patients eligibility to bypass phase 1 PACU.[3] Only patients with an Aldrete score of 9 or higher and not requiring treatment of pain with intravenous morphine sulfate (visual analog scale [VAS] score < 3) were eligible to bypass phase 1 PACU. Once in phase 2 PACU, patients were similarly assessed by the same personnel at 15-min intervals to determine whether they met discharge criteria. There was no minimum time requirement for patients to remain in phase 2 PACU. Rather, for home readiness, the patient was required to meet a score of more than 9 on the postanesthesia discharge scoring system (appendix 2).[4] Home readiness and the decision to discharge were made by the phase 2 PACU nursing personnel, who were unaware of the purpose of the study. Voiding was not required before discharge.[5]

If patients reported postoperative pain, medications were offered according to the following protocol: In phase 1 PACU, morphine sulfate (1–2 mg) was administered by intravenous injection every 5–10 min until the patient was comfortable (VAS score ≤ 2). The pain management protocol in phase 2 PACU and at home consisted of acetaminophen (325 mg) with codeine (30 mg) every 4 h as needed.

The quantity of analgesics used during the preoperative, intraoperative, and postoperative phases was noted. Adverse events such as nausea, vomiting, hypotension (mean blood pressure $< 30\%$ of preoperative), bradycardia (heart rate < 60 beats/min), respiratory depression (respiratory rate < 10 breaths/min), hypoxia (oxygen saturation < 90), apnea, or dizziness were noted. Relevant time intervals, such as operating room (OR) time, recovery time, and discharge time where recorded using the data from the automated record-keeping system.[6] Data were also collected on the number of patients able to bypass phase 1 PACU. Pain scores were determined using a VAS (1–10) on arrival to phase 1 PACU and at the time of discharge. The Mini-Mental State Examination[7] was administered by unblinded research assistants in all patients before surgery, on arrival to phase 1 PACU, and again in phase 2 PACU immediately before discharge. The Mini-Mental State Examina-

Table 1. Demographic Characteristics and Surgical Procedures

	Infraclavicular Block (n = 25)	General Anesthesia (n = 25)	P Value
Gender (% male)	12 (48)	11 (44)	ns
Age, yr	45 ± 15	40 ± 16	ns
Height, cm	173 ± 10	170 ± 12	ns
Weight, kg	81 ± 18	77 ± 15	ns
ASA physical status			
I	11 (44)	17 (68)	ns
II	13 (52)	8 (32)	
III	1 (4)	0	
Surgical procedure			
Carpal tunnel release	7 (28)	5 (20)	ns
Metacarpal fracture ORIF	7 (28)	6 (24)	
Ganglion cyst excision	6 (32)	10 (40)	
Wrist mass excision	5 (20)	4 (16)	

Categorical data presented as n (%), and continuous variables presented as mean ± SD.

ns = not significant; ORIF = open reduction and internal fixation.

tion is a quantitative test of cognitive function that is suitable for initial and serial measurements of mental function and can demonstrate worsening or improvement of cognitive function over time.[7] Before discharge, patients were also asked to subjectively rate their energy levels (as self-reported on a VAS; score 1–10). A research assistant, blinded to the type of anesthetic used, collected data on highest pain VAS scores and daily requirement for pain tablets at 24, 48, and 72 h after surgery during a telephone interview with the patients. Data on any complications (prolonged numbness, radiating pain in the distribution of the brachial plexus, motor weakness), satisfaction with anesthesia, and willingness to have the same anesthesia for their consecutive surgeries was collected at 2 weeks after surgery.

Statistics

Sample size estimates were based on time to home readiness and discharge (in minutes) because these variables were of primary interest for this study. It was estimated that a sample size of 18 per group would provide 80% power to detect a clinically meaningful difference of 90 min (within-group SD, 60 min) at $\alpha = 0.001$. The probability of a type I error was set low to accommodate the multiple comparisons that were planned, particularly for the targeted time measures (*e.g.*, time to ambulation, time to fluid and solid intake). Furthermore, the sample size was increased to 25 per group, as an additional assurance that α would not be inflated when demographic and postoperative data were analyzed.

Discrete categorical data are presented as number (percent); continuous data are presented as mean ± SD. Differences in demographic, surgical, anesthetic, and postoperative data were tested by independent Student *t* test (continuous data) or by chi-square (categorical data) and Fisher exact test (when appropriate). For descriptive purposes, *P* value differences less than 0.05 are noted in the tables. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS for Windows, version 11.0.1, Chicago, IL, 2001).

Results

Fifty-two patients were enrolled in the study. Two patients were excluded from analysis: One patient in the INB group had a failed block and required GA, and the other patient in the GA group had respiratory obstruction and negative pressure pulmonary edema and required emergent tracheal intubation and 24-h admission to the intensive care unit. There were no significant differences between the two groups in demographic characteristics, American Society of Anesthesiologists physical status, and types of surgical procedures performed (table 1).

Total OR time did not differ significantly between the two groups, although mean induction time was longer (5 min) in patients given INB as compared with those given GA (fig. 1). Patients in the INB group received 4.2 ± 1.3 mg midazolam and 550 ± 213 μg alfentanil for block induction, followed by a median of 148 mg (range, 0–706 mg) propofol during surgery, whereas the patients in the GA group received 2.2 ± 1.0 mg midazolam and 138 ± 78 μg fentanyl intraoperatively. A greater proportion of patients in the INB group (76%) met criteria enabling them to bypass phase 1 PACU as compared with only 25% in the GA group (table 2) ($P < 0.001$). The phase 1 PACU times for patients who did not meet criteria to bypass the PACU did not vary significantly between the GA (n = 19; median, 70 min; range,

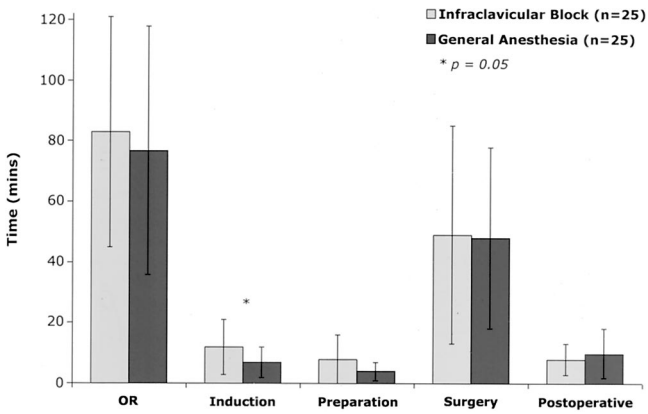

Fig. 1. Perioperative time intervals. Induction = time from patient entry into operating room to completion of anesthesia induction; OR = time from patient entry into operating room to patient exit from operating room; postoperative = time from patient exit from operating room to anesthesia care assumed by nursing; preparation = time from completion of anesthesia induction to patient prepared for surgery; surgery = duration of surgical procedure (from incision to closure).

Table 2. Incidence of Common Side Effects and Satisfaction Score

	Regional Anesthesia (n = 25)	General Anesthesia (n = 25)	P Value
% Bypass PACU	19 (76)	6 (24)	0.001
Nausea/Vomiting	2 (8)	8 (32)	0.001
Sore throat	1 (4)	9 (36)	
Fatigue	8 (32)	17 (68)	
Low concentration	2 (8)	14 (56)	
Satisfaction score			
0–2	0	1 (5)	ns
3–7	3 (14)	6 (30)	
8–10	18 (86)	13 (65)	
Repeat technique*			
Yes	17 (81)	10 (50)	0.05
No	4 (19)	10 (50)	

Categorical data presented as n (%), and continuous variables presented as mean ± SD. Four patients in the infraclavicular brachial plexus block group and five patients in the general anesthesia group were not available to collect information 2 weeks after surgery.

* Whether the patient would have the same anesthesia technique for his/her consecutive surgery.

ns = not significant; PACU = postanesthesia care unit.

30–330 min) and INB groups (n = 6; median, 72 min; range, 50–165). Adverse events, such as nausea, vomiting, sore throat, fatigue, and inability to concentrate occurred less frequently in patients undergoing INB as compared with those undergoing GA (table 2). On arrival to the PACU, fewer patients (3%) undergoing INB had a VAS score greater than 3 as compared with 43% in the GA group ($P < 0.001$). None of the patients in the INB group requested treatment for pain while in the hospital, compared with 12 (48%) in the GA group ($P < 0.001$). Of these, 6 patients had VAS score greater than 3 (VAS 6.2 ± 2) and required 9.3 ± 5.6 mg morphine sulfate (range, 4–20 mg) to achieve adequate pain relief. Of these, 3 patients had pain on arrival to PACU despite the local wound infiltration by the surgeons at the end of the procedure.

Patients undergoing INB tolerated intake of fluids and solids sooner than patients undergoing GA (fig. 2). In addition, patients in the INB group were able to ambulate sooner (82 ± 41 min) as compared with 145 ± 70 min for those in the GA group ($P < 0.001$). Time to home readiness and actual discharge time were shorter for patients in the INB group (100 ± 44 and 121 ± 37 min) compared with those in the GA group (203 ± 91 and 218 ± 93 min) (fig. 2). Patients in the INB group performed better on the mental acuity test on arrival to the phase 1 PACU. Of note, fewer patients in the regional anesthesia group reported inability to concentrate (0–7 on a 10-point scale sum of registration, attention and calculation, and recall in the Mini-Mental State Examination[7]) in phase 1 PACU or phase II PACU than patients in the GA group (2 *vs.* 14, respectively; $P < 0.001$). However, after meeting home discharge criteria in phase 2 PACU, there was no significant difference between the two groups. Eleven patients (44%) in the INB group had full return of motor and sensory function of the hand at the time of discharge.

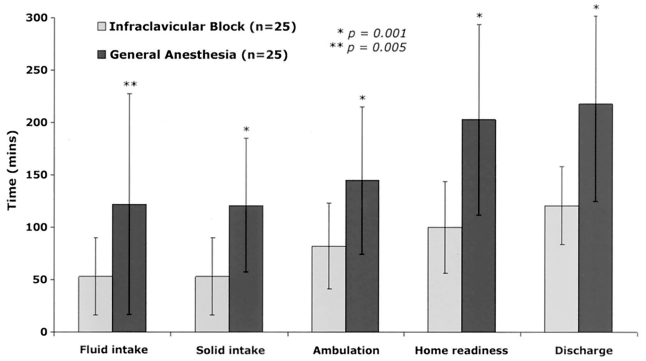

Fig. 2. Time to oral intake, ambulation, home readiness, and discharge home. All time intervals calculated from end of anesthesia.

Table 3. Pain Scores and Analgesic Requirement after Discharge

	Regional (n = 25)	General (n = 25)	P Value
Pain score at 24 h			
Low (0–2)	9 (38)	12 (48)	ns
Moderate (3–7)	12 (50)	13 (52)	
High (8–10)	3 (12)	0	
Pain medication at 24 h (pills)			
None	4 (17)	3 (12)	ns
1–3	11 (46)	12 (48)	
4–7	8 (33)	9 (36)	
8–10	1 (4)	1 (4)	
Pain score at 48 h			
Low (0–2)	12 (50)	14 (56)	ns
Moderate (3–7)	10 (42)	11 (44)	
High (8–10)	2 (8)	0	
Pain medication at 48 h (pills)			
None	9 (38)	6 (24)	ns
1–3	9 (38)	12 (48)	
4–7	4 (16)	6 (24)	
8–10	2 (8)	1 (4)	
Pain score at 72 h			
Low (0–2)	21 (88)	14 (58)	0.02
Moderate (3–7)	3 (13)	9 (38)	
High (8–10)	0	1 (4)	
Pain medication at 72 h (pills)			
None	17 (71)	8 (33)	0.02
1–3	5 (21)	9 (38)	
4–7	1 (4)	6 (25)	
8–10	1 (4)	1 (4)	

Categorical data presented as n (%), and continuous variables presented as mean ± SD.

ns = not significant.

On follow-up, there was no significant difference between the 2 groups in pain VAS scores or quantity of analgesics consumed at 24 or 48 h (table 3). However, by 72 h, patients who had INB reported less pain and had taken fewer analgesics than those who had GA. None of

the patients reported any neurologic complications (persistent numbness, pain, or weakness in the extremity).

Discussion

The change in emphasis from inpatient to ambulatory surgical care represents one of the most significant changes in surgical and anesthesia practice. Rapid recovery, adequate analgesia, avoidance of nausea and vomiting, and timely discharge after ambulatory surgery are some of the essential ingredients in a successful ambulatory anesthesia practice.[8–10] Fast-tracking is an often-used benchmark test of such a success and refers to the patient being able to bypass the more costly and labor-intensive phase 1 PACU and go directly to phase 2 PACU.[11] Using these criteria, in our study, outpatients undergoing hand and wrist surgery who received INB had a superior recovery profile compared with patients who received GA.

This is most likely because patients in the INB group were more alert on arrival to the PACU and had less pain, nausea, and vomiting than did patients in the GA group. Of note, almost half of the patients in the GA group had significant pain in the PACU and required treatment despite infiltration of the wound with local anesthetic by the surgeons. Similarly to the PACU bypass criteria recently published in ANESTHESIOLOGY,[12] three patients who had pain on arrival required treatment with intravenous morphine sulfate and could not bypass the PACU despite achieving an adequate Aldrete score.

Some commonly voiced disadvantages of peripheral nerve blocks include the additional time required to perform the blocks and the potential that patients receiving blocks may have superior pain relief in the immediate postoperative period but may ultimately have more pain when the blocks wear off. Neither of these two common assertions proved true in our study. For example, although some additional time was required to perform the blocks as compared with induction of GA and securing the airway, total OR times were similar, despite the fact that the blocks were performed in the OR. This is undoubtedly due to the combination of a fast-acting local anesthetic in INB and the fact that surgeons could proceed with surgical preparation without having to wait to document the onset of full surgical anesthesia. Conceivably, inducing blocks preoperatively in the holding area rather than in the OR would further decrease OR time. In addition, emergence time (time from end of surgical dressing until OR exit) is likely faster after INB *versus* after GA, making for a more prompt OR exit, which can effectively offset the additional induction time needed to place the block in the OR.

Patients undergoing INB as a sole anesthetic, even with a short-acting local anesthetic, had far superior analgesia in the immediate postoperative period than did those in the GA group who had wound infiltration with a long-acting local anesthetic. Moreover, despite the fact that 44% of patients in the INB group regained full sensation of the operative extremity, none required analgesics before discharge. However, after discharge, patients from both groups had a similar degree of pain and need for oral analgesics during the first 48 postoperative hours. Interestingly, however, patients in the INB group had less pain and a decreased need for oral analgesics at 72 postoperative hours.

Despite advances in anesthesia, postoperative nausea and vomiting remain common and troubling problems that result in distress to patients and frequently delay discharge after ambulatory surgery.[13–15] In our study, patients given an INB combined with intravenous sedation with propofol had significantly less risk of postoperative nausea and vomiting (8%) than did patients given GA (32%), despite prophylactic use of dolasetron in patients given GA. Although hand surgery is not typically thought to result in a high incidence of postoperative nausea and vomiting,[16] the higher incidence of postoperative pain requiring treatment with opioids in the GA group may have contributed to the higher incidence of postoperative nausea and vomiting.[17] In addition, although retention of liquids and solids as a prerequisite for discharge has recently been questioned, oral intake plays an important role in patient comfort after surgery and prolonged perioperative fasting.

It could be argued that the advantages of INB in this study would be less pronounced had another GA technique been used, or perhaps had the GA been more objectively titrated using bispectral analysis of the electroencephalogram.[18] However, the ability of desflurane and sevoflurane to result in a higher rate of fast-tracking than propofol-based techniques, as well as the limitations of bispectral analysis of the electroencephalogram, have both been well documented.[19,20] Moreover, because postoperative pain is one of the most common reasons for hospital admission or delays in discharge,[21] selection of another GA technique would be unlikely to result in less postoperative pain. It is possible that a multimodal approach to postoperative pain management (including perioperative administration of antiinflammatory drugs, in addition to acetaminophen with codeine) could have resulted in better analgesia in the GA group. However, similar beneficial effects would have also been expected in patients in the INB group, particularly if these patients had also received local anesthetic infiltration with 0.25% bupivacaine at the conclusion of the surgical procedure.

In summary, we found that INB with a short-acting local anesthetic produced time-efficient anesthesia, faster recovery, fewer adverse events, better analgesia, and greater patient acceptance than GA followed by wound infiltration with a local anesthetic in outpatients undergoing hand and wrist surgery.

Appendix 1. Modified Aldrete Scoring System for Determining When Patients Are Ready for Discharge from the Postanesthesia Care Unit

Discharge Criteria	Score
Activity: able to move voluntarily or on command	
Four extremities	2
Two extremities	1
Zero extremities	0
Respiration	
Able to deep breathe and cough freely	2
Dyspnea, shallow, or limited breathing	1
Apneic	0
Circulation	
Blood pressure ±20 mm of preanesthetic level	2
Blood pressure ±20–50 mm of preanesthetic level	1
Blood pressure ±50 mm of preanesthetic level	0
Consciousness	
Fully awake	2
Arousable on calling	1
Not responding	0
Oxygen saturation	
Able to maintain O_2 > 92% on room air	2
Needs O_2 inhalation to maintain O_2 saturation > 90%	1
O_2 saturation < 90% even with O_2 supplementation	0

A score of 9 or greater was required for discharge.

From Aldrete[3]; used with permission.

Appendix 2. Postanesthesia Discharge Scoring System for Determining Home Readiness

Discharge Criteria	Score
Vital signs	
Vital signs must be stable and consistent with age and preoperative baseline.	
Blood pressure and pulse within 20% of preoperative baseline	2
Blood pressure and pulse 20–40% of preoperative baseline	1
Blood pressure and pulse > 40% of preoperative baseline	0
Activity level	
Patient must be able to ambulate at preoperative level.	
Steady gait to dizziness, or meets preoperative level	2
Requires assistance	1
Unable to ambulate	0
Nausea and vomiting	
Patient should have minimal nausea and vomiting before discharge.	
Minimal: successfully treated with or without medication	2
Moderate: successfully treated with intramuscular medication	1
Severe: continues after repeated treatment	0
Pain	
Patient should have minimal or no pain before discharge.	
The level of pain that the patient has should be acceptable to the patient.	
The location, type, and intensity of the pain should be consistent with anticipated postoperative discomfort.	
Pain acceptable	2
Pain not acceptable	1
Surgical bleeding	
Postsurgical bleeding should be consistent with expected blood loss for the procedure.	
Minimal: does not require dressing change	2
Moderate: up to two dressing changes required	1
Severe: more than three dressing changes required	0

Maximum score = 10; patients with scores of 9 or greater are fit for discharge.

From Marshall and Chung[4]; used with permission.

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