The Effect of Anesthetic Technique on Recovery After Orthognathic Surgery: A Retrospective Audit

Soudeh Chegini,* Kevin D. Johnston,† Athanasios Kalantzis,‡ and Daljit K. Dhariwal§

*Foundation Doctor, Heatherwood and Wexham Park Hospitals NHS Foundation Trust, †Specialist Registrar, Nuffield Department of Anaesthetics, ‡Specialist Registrar, Department of Oral and Maxillofacial Surgery, and §Consultant, Department of Oral and Maxillofacial Surgery, The John Radcliffe Hospital, Headley Way, Headington, Oxford, England

We audited the recovery characteristics of 51 patients who had undergone orthognathic maxillofacial surgery at a single center. Patients whose anesthesia had been maintained with intravenous propofol and remifentanyl ($n = 21$) had significantly higher pain scores during the first 4 hours after surgery than those whose anesthesia was maintained with volatile inhalational agents and longer-acting opioids ($n = 30$) ($P = .016$). There was a nonsignificant trend towards shorter recovery times in the former group, while there were no differences in early postoperative opioid usage, hemodynamic parameters, or postoperative nausea and vomiting. Given that our data were collected retrospectively and without the ability to control for potential confounders, we interpret the results with caution. Notwithstanding these limitations, we believe this is the first report comparing the effects of different opioid-based anesthetic regimens on early recovery from orthognathic surgery, and we believe this report may be used as the starting point for a controlled study.

Key Words: Propofol; Remifentanyl; Inhalation anesthesia; Orthognathic surgery.

Maxillary and mandibular osteotomies may be associated with significant blood loss and postoperative airway compromise. Deliberate hypotensive anesthesia, head up tilt, and local anesthesia with vasoconstrictor can reduce blood loss to the extent that blood transfusion is now uncommon.¹ It is, however, important to avoid excessive opioid-induced postoperative narcosis and respiratory depression associated with these techniques. Anesthetic maintenance with propofol and remifentanyl is fast becoming the technique of choice for orthognathic surgery in our institution since it is perceived that the very short half-life of the latter allows stable hypotensive conditions intraoperatively and a rapid return of respiratory function postoperatively. However, the short half-life of remifentanyl means that longer-acting opioids must still be administered at the end of surgery. The risk of respiratory depression from opioid overdose, pain from un-

derdosage, and postoperative nausea and vomiting (PONV) are therefore not eliminated. Data comparing remifentanyl with other opioids are available for many different types of surgery,² but there is little in the literature related to maxillofacial surgery where respiratory complications can be more serious.^{3,4} To ensure that good intraoperative conditions with propofol and remifentanyl are not being achieved at the expense of detrimental recovery characteristics in our institution, we conducted a retrospective audit of postoperative pain, nausea, vomiting, and respiratory problems in a recent sample of patients who had received propofol- and remifentanyl-based anesthesia for orthognathic surgery and compared this with data from a historic cohort of patients who had received maintenance solely with inhalational agents and longer-acting opioids.

METHODS

Data were collected retrospectively from the anesthetic charts, drug charts, and recovery observation charts of

Received March 7, 2011; accepted for publication January 13, 2012.

Address correspondence to Kevin D. Johnston; kevinjohnston@googlemail.com.

Anesth Prog 59:69–74 2012

© 2012 by the American Dental Society of Anesthesiology

ISSN 0003-3006/12

SSDI 0003-3006(12)

Table 1. Patient Demographics and Intraoperative Details in the 2 Groups

	<i>Maintenance With Propofol and Remifentanyl (n = 21)</i>	<i>Maintenance With Volatile Inhalational Agents (n = 30)</i>
Male subjects		
Number (%)	10 (48)	13 (44)
Weight		
Mean (range), kg	82 (53–105), n = 9	67 (39–113), n = 13
Surgery type		
Number (%)		
Mandibular osteotomy	6 (29)	7 (23)
Maxillary osteotomy	1 (5)	3 (10)
Maxillary-mandibular osteotomy	14 (66)	20 (67)
Nitrous oxide used		
Number (%)	0 (0)	15 (50)
Intraoperative morphine		
Number (%)	3 (14)	25 (83)
Mean dose (range), mg	13 (10–20)	12 (5–20)
Intraoperative fentanyl		
Number (%)	5 (24)	18 (60)
Mean dose (range), µg	85 (75–100)	158 (100–300)
Intraoperative morphine equivalent (when used)		
Mean dose (range), mg	10 (7–20)	20 (10–40)

patients who had undergone mandibular (any type), maxillary (LeFort I), or maxillomandibular osteotomy at Oxford Radcliffe Hospitals in the periods 1997–2003 and 2008–2010. The 1997–2003 time interval was chosen in order to retrieve enough patients having inhalational anesthesia. Data were collected using the proforma shown in the appendix. Patients who underwent anesthesia with propofol infusion but without remifentanyl, those who received volatile anesthetics plus remifentanyl, and those with insufficient data on anesthetic agents were excluded. The remaining 51 patients were divided into 2 groups, one consisting of patients who had received a propofol- and remifentanyl-based anesthetic, and the other of patients who had received neither propofol nor remifentanyl as part of their maintenance anaesthesia. Other variables recorded were recovery time (time between the first and last set of observations recorded by recovery staff), occurrence of nausea and vomiting, highest pain score (subjective rating of severe = 3, moderate = 2, mild = 1, none = 0), highest heart rate, lowest recorded peripheral oxygen saturation, and total opioid dose administered in the first 4 hours postoperatively. For the latter, it was assumed that 10 µg of fentanyl and 3 mg of oral morphine were equivalent to 1 mg of intravenous morphine. The distribution of variables was assessed using the Shapiro-Wilk *W* test. Differences in parametric data (heart rate) were analyzed for significance using the Student's *t* test, and nonparametric data (pain scores, recovery time, lowest saturations recorded in recovery, and postoperative equivalent morphine usage) were

analyzed using the Mann-Whitney *U* test. Data on the presence or absence of nausea and/or vomiting was assessed with the Fisher exact test. Analyses were performed on SPSS statistics software (IBM Corporation, Armonk, NY).

RESULTS

There were 30 patients in the inhalational anesthesia group (28 of these yielded from the 1997–2003 cohort) and 21 patients in the propofol and remifentanyl group (all from the 2008–2010 cohort). The demographics and description of intraoperative details (use of opioids in particular) in the 2 groups are illustrated in Table 1. Sex and type of operation were similarly distributed between the 2 groups. The average weight of patients in the intravenous (IV) maintenance group was higher, while nitrous oxide was used only in the inhalational agent maintenance group. Intraoperative morphine was used more often and in larger doses in the inhalational agent maintenance group, and the same applied to fentanyl and when both agents were combined (morphine equivalents). Of the patients in the inhalational maintenance group, 43% were administered both intraoperative morphine and fentanyl, while in the IV maintenance group, patients received either one or the other, and in 13 patients (62%) longer-acting opioids were not administered intraoperatively.

Results related to the postoperative variables are illustrated in Table 2. There was a trend towards shorter time spent in recovery in the IV group compared to the

Table 2. Results Related to Recovery in the 2 Groups

	Maintenance With Propofol and Remifentanyl (n = 21)	Maintenance With Inhalational Agents (n = 30)	Statistical Test And Significance
Highest postoperative heart rate			Student's <i>t</i> Test
Mean (range), beats/min	98 (70–160)	93 (70–120)	<i>P</i> = .228
Highest postoperative pain score			Mann-Whitney <i>U</i> Test
Median ([IQR] range)	2 ([1–2] 0–3)	1 ([0–2] 0–3)	<i>P</i> = .016
PONV			Fisher exact test
Number (%) of patients with at least one episode of			
Nausea	3 (14)	3 (10)	<i>P</i> = .68
Vomiting	0 (0)	1 (3)	
Both	0 (0)	1 (3)	
Time spent in recovery			Mann-Whitney <i>U</i> Test
Median ([IQR] range), min	65 ([52–88] 35–120)	93 ([53–135] 30–455)	<i>P</i> = .078
Lowest saturations in recovery			Not applicable
Median ([IQR] range), %	95 ([94–96] 85–99)	96 ([94–99] 85–100)	Mann-Whitney <i>U</i> Test
(Equivalents) of morphine administered postoperatively			
Median ([IQR] range), mg	10 ([0–15] 0–43)	5 ([0–12] 0–31)	<i>P</i> = .39

inhalational maintenance group, though this fell just short of significance (*P* = .078). Median recovery time for the IV group was 65 minutes (interquartile range [IQR] 57–88; range 35–120) compared with the inhalational group, which was 93 minutes (IQR 53–135; range 30–455). During the first 4 hours after surgery, highest recorded pain scores were higher in the IV group than in the inhalational group and were 2 (IQR 1–2; range 0–3) and 1 (IQR 0–2; range 0–3), respectively (*P* = .016). There was, however, no difference in either highest recorded heart rate or total morphine (equivalent) administered during the first 4 hours after surgery. The range of lowest recorded peripheral hemoglobin oxygen saturation appeared broadly similar between the groups, and no statistical analysis was applied, in part because it was difficult to reliably establish what form of oxygen supplementation was being employed for individual patients at the time of the readings. The incidence of PONV was also similar between the 2 groups.

DISCUSSION

Hypotensive anesthesia can reduce blood loss during orthognathic surgery avoiding the need for blood transfusion in otherwise fit and healthy young patients.^{1,5} This is probably due to the combination of reduced bleeding directly and shorter duration of surgery as a result of better operating conditions.¹ The use of high concentrations of volatile anesthetic agents in combination with morphine to achieve hypotensive

conditions has been recognized for over 30 years,^{1,5} but rates of postoperative nausea and vomiting can be high.^{4,6} Remifentanyl is a μ -opioid receptor agonist with an extremely short half-life secondary to its metabolism by nonspecific hepatic and plasma esterases.⁷ It can be used to achieve profound blunting of the hemodynamic response to surgical stimuli intraoperatively but is cleared rapidly enough after stopping the infusion for levels to be clinically ineffective within minutes. It has the potential to facilitate hypotensive operating conditions without the postoperative consequences of high-dose volatile agents and morphine, and for these reasons it is increasingly being used for orthognathic surgery.^{3,8} On the other hand, effective analgesia is still required in the postoperative period,^{9,10} necessitating the administration of longer-acting opioids with the potential for adverse effects of perioperative opioids to occur in the postoperative period and in particular during recovery. Differences in recovery characteristics between remifentanyl and other opioids have been the subject of a recent systematic review²; however, in the context of maxillofacial surgery, where it may be argued that postoperative respiratory and gastrointestinal complications can be at their most dangerous, studies have been sparse.

We found that following orthognathic surgery, patients who had had their anesthesia maintained with propofol and remifentanyl had significantly higher highest recorded pain scores within the first 4 hours postoperatively. One explanation for these differences is that less morphine and fentanyl was administered to the patients receiving a propofol and remifentanyl-maintained anesthetic.

ic, resulting in more patients experiencing discomfort on waking. Farah et al¹¹ actually reported higher pain scores after orthognathic surgery with remifentanyl than with no longer-acting opioid (all received substantial local anaesthesia). Although it is not clear whether their results were significant, the possibility that remifentanyl could even contribute to a state of acute opioid tolerance, although controversial, also has to be considered. Of the subjective pain score employed in our hospital (severe = 3, moderate = 2, mild = 1, none = 0), it could be argued that a 4 value semiquantitative system lacks the discriminatory ability of decimal pain scoring systems such as the visual analog scale and numerical rating scale. Nevertheless, this standardized system has been in use for a number of years in perioperative documentation across different departments in our hospital and is familiar to ward and recovery staff who use it routinely to score patients' pain. For these reasons we considered it a valid tool to use in a retrospective analysis. Interestingly, the total dose of opioids administered in the first 4 hours after surgery (adjusted for morphine equivalence) did not differ between the 2 groups. Since postoperative fentanyl and morphine were administered on an "as required" basis, this might suggest that patient discomfort was, over time, fairly similar between the 2 groups. It is possible that greater doses of opioids could have been administered sooner to those recovering from remifentanyl, yet later on to patients who had received more morphine or fentanyl intraoperatively. We would not have been able to discriminate this using our methods. Assumptions about opioid dose conversions may not always be accurate (pharmacodynamics and pharmacokinetics may vary among patients), but potential errors would be small over short periods of time, and previous studies have used similar conversion factors.^{12,13} Demands for opioids after orthognathic surgery have also been shown to be related to levels of preoperative anxiety,¹⁴ but a bigger limitation of our study is that we did not take into account the use of nonopioid analgesia (paracetamol/acetaminophen and nonsteroidal anti-inflammatory drugs) in the early postoperative period. We assessed maximum recorded heart rate during the first 4 hours as an objective indicator of pain. Mean hemodynamic values were similar in the 2 groups. Heart rate alone is a very crude surrogate measurement of pain as the causes of postoperative tachycardia include hypovolemia, anxiety, and nausea. Furthermore, we did not attempt to establish baseline preoperative heart rate measurements as these were inconsistently recorded on anesthetic charts, a further limitation of a retrospective study. Patients are suitable for discharge from recovery to the ward when they are safe with respect to their hemodynamic stability, spontaneous airway maintenance, effective ventilation, and neurologic appropriateness and also are comfortable and not in acute pain. Despite the difference in pain scores,

median time spent in recovery by patients whose anesthetic had been maintained with propofol and remifentanyl was actually half an hour less than those whose anesthetic had been maintained with volatile inhalational agents. Although this did not reach significance, it is in keeping with previous work,¹¹ and although immediate pain scores were higher in this group, discharge times would suggest that discomfort was rapidly corrected.

The effect of residual anesthetic agents on upper airway physiology is particularly important following orthognathic surgery. Patients who mouth breathe before surgery have a reduced capacity to do so postoperatively if in intermaxillary fixation (IMF), resulting in reduced tidal and minute volumes and elevations in end tidal carbon dioxide concentration.¹⁵ These observations do not occur in awake healthy volunteers in IMF, and so either postoperative airway edema or the respiratory depressant effects of anesthetic agents are important additional factors.¹⁵ Although IMF is rarely applied following orthognathic surgery in our hospital, it is important to keep the postoperative respiratory depressant effects of anesthesia to a minimum. Following other types of surgery, spontaneous respiration is resumed faster following remifentanyl than other opioids, and postoperative respiratory depression is not greater despite a higher need for additional opioids.² We made no attempt to clarify changes in oxygen flow rates administered by our recovery staff, and it is quite possible that we may have overlooked relatively slowly occurring episodes of desaturation. Nevertheless, if significant desaturations had occurred following bolus administrations of opioids, it is likely that recovery staff would have documented the low saturation before taking appropriate action. A similar proportion of patients recovering from IV and inhalational anesthesia (19 and 23%, respectively) had oxygen saturations of less than 95% on at least one occasion and one from each group desaturated to 85%. Since we could not accurately determine how much supplemental O₂ was being delivered at the time of the recordings, we did not attempt to draw any further conclusions from these variables.

The reported incidence of PONV after orthognathic surgery varies from 7¹⁶ to 40%^{4,11} with steroid prophylaxis and up to 83% with no antiemetic prophylaxis.¹⁷ In our patients, there was no significant difference in the incidence of early PONV between those given propofol and remifentanyl intraoperatively (14%) and those receiving volatile inhalational agents and longer acting opioids (10%), but it is noteworthy that the incidences were at the lower end of previously reported ranges regardless of the anesthetic technique used. Although we did not specifically seek to clarify antiemetic prophylaxis given to individual patients, the use of

at least one agent for this type of surgery is almost universal in our department.

The main shortcoming of this study is that the data were collected retrospectively without the ability to control for potential confounding factors and biases. Since the majority of anesthetics for orthognathic surgery are now based on IV maintenance techniques (or at least one of a choice of propofol or remifentanyl) in our institution, we deliberately selected patients from an older time cohort in order to generate enough data relating to patients whose anesthetic was maintained with volatile agents. Although done in an otherwise random fashion, we have to acknowledge that some or all of the differences we identified could be due to historical bias. The number of patients was small, and the analysis may lack power to detect differences in the variables where none were found. Given the study's limitations, we would interpret these findings very cautiously, but since we also believe this to be the first study to look specifically at the effects of different opioid-based anesthetic regimens on recovery observations after orthognathic surgery, it may be useful as the basis for a future prospective investigation.

Conflicts of interest

None of the authors have conflicts of interest to declare.

REFERENCES

1. Yu CNF, Chow TK, Kwan ASK, Wong SL, Fung SC. Intra-operative blood loss and operating time in orthognathic surgery using induced hypotensive general anaesthesia: prospective study. *Hong Kong Med J*. 2000;6:307–311.
2. Komatsu R, Turan AM, Orhan-Sungur M, McGuire J, Radke OC, Apfel CC. Remifentanyl for general anaesthesia: a systematic review. *Anaesthesia*. 2007;62:1266–1280.
3. Yamakage M, Murouchi T, Michifuri Y, Hiratsuka H, Namiki A. Usefulness of remifentanyl anesthesia in oral surgery—comparison of sevoflurane and propofol. *Anesthesiology*. 2008;109:A1153.
4. Silva AC, O’Ryan F, Poor DB. Postoperative nausea and vomiting (PONV) after orthognathic surgery: a retrospective study and literature review. *J Oral Maxillofac Surg*. 2006;64:1385–1397.
5. Washburn MC, Hyer RL. Deliberate hypotension for elective major maxillofacial surgery: a balanced halothane and morphine technique. *J Maxillofac Surg*. 1982;10:50–55.
6. Apfel CC, Kranke P, Katz MH, et al. Volatile anaesthetics may be the main cause of early but not delayed postoperative vomiting: a randomised controlled trial of factorial design. *Br J Anaesth*. 2002;88:659–668.
7. Peck TE, Hill SA, Williams M. Analgesics. In: Peck TE, Hill SA, & Williams M, eds. *Pharmacology for Anaesthesia and Intensive Care*. 3rd ed. , Cambridge, England: Cambridge University Press, 2008, 135–162.
8. Choi SH, Lee WK, Lee KY, Shin BH, Lee SJ. Efficacy of remifentanyl-induced controlled hypotension for orthognathic two jaw surgery. *Korean J Anesthesiol*. 2007;52:62–66.
9. Nagatsuka C, Ichinohe T, Kaneko Y. Preemptive effects of a combination of preoperative diclofenac, butorphanol, and lidocaine on postoperative pain management following orthognathic surgery. *Anesth Prog*. 2000;47:119–124.
10. Van Lancker P, Abeloos JVS, De Clercq CAS, Mommaerts MY. The effect of mandibular nerve block on opioid consumption, nausea and vomiting in bilateral mandibular osteotomies. *Acta Anaesthesiol Belg*. 2003;54:223–226.
11. Farah GJ, de Moraes M, Filho LI, et al. Induced hypotension in orthognathic surgery: a comparative study of 2 pharmacological protocols. *J Oral Maxillofac Surg*. 2008;66:2261–2269.
12. Precious DS, Multari J, Finley GA, McGrath P. A comparison of patient-controlled and fixed schedule analgesia after orthognathic surgery. *J Oral Maxillofac Surg*. 1997;55:33–39.
13. Ruiz JR, Kee SS, Frenzel JC, et al. The effect of an anatomically classified procedure on antiemetic administration in the postanesthesia care unit. *Anesth Analg*. 2010;110:403–409.
14. Geha H, Nimeskern N, Beziat JL. Patient-controlled analgesia in orthognathic surgery: evaluation of the relationship to anxiety and anxiolytics. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2009;108:33–36.
15. Yamaguchi H. Effects of intermaxillary fixation during orthognathic surgery on respiratory function after general anaesthesia. *Anesth Prog*. 2001;48:125–129.
16. Ichinohe T, Kaneko Y. Nitrous oxide does not aggravate postoperative emesis after orthognathic surgery in female and non-smoking patients. *J Oral Maxillofac Surg*. 2007;65:936–939.
17. Piper SN, Röhm K, Boldt J, et al. Postoperative nausea and vomiting after surgery for prognathism: Not only a question of patients’ comfort. A placebo-controlled comparison of dolasetron and droperidol. *J Craniomaxillofac Surg*. 2008;36:173–179.

Appendix. Data collection proforma**Demographics**

Hospital number_____

Date of birth_____

Male / Female

Patient's weight____(kg)

Date of surgery _____

Mandibular osteotomy (BSSO/VSSO) / Maxillary osteotomy (Le Fort I) / Bimaxillary osteotomy

From anaesthetic chart(Circle **all** that were used) Remifentanyl / propofol infusion (NB **not** single dose) / isoflurane / sevoflurane / nitrous oxide (N₂O)

Total dose of morphine____(mg)

Total dose of fentanyl____(μg)

Post-operative observations (during 1st 4 hours starting from 1st set observations in recovery)Time between 1st and last set of observations in recovery____(mins)

Total dose of morphine given in recovery____(mg)

Highest heart rate recorded____(beats/min)

Lowest Oxygen saturation recorded____(%)

Highest pain score recorded 0 / 1 / 2 / 3

Nausea (N) documented yes / no

Vomiting (V) documented yes / no