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A Comparison of Anesthetic Techniques for Awake Intubation in Neurosurgical Patients

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Summary: Two different methods of achieving upper airway anesthesia for awake fiberoptic intubation were prospectively compared in patients undergoing surgery for cervical spine instability. Forty patients were randomized to either topical anesthesia or nerve block groups. Topical anesthesia patients were administered nebulized 4% lidocaine (~20 ml) via the oropharynx plus a transtracheal injection of 4% lidocaine (3 ml). Nerve block patients underwent bilateral glossopharyngeal and superior laryngeal nerve blocks with 2% lidocaine (0.5–2 ml per injection site) plus a transtracheal injection of 4% lidocaine (3 ml). The quality of anesthesia for intubation was graded by observers blinded to group assignment. Mean arterial pressure, heart rate, Pao_2, $Paco_2$, pHa, Spo_2, and plasma lidocaine concentrations were measured during the intubation sequence. Patient recall of intubation and discomfort were assessed during the postoperative period with visual analog scales. Time required for successful intubation and quality of intubation were not different between groups. Physiologic values for the two groups were similar. The mean total dose of lidocaine in the topical anesthesia group was ~2 times greater than that in the nerve block group (815 versus 349 mg; $p < 0.0001$). In contrast, mean plasma lidocaine concentration at initiation of intubation in the topical anesthesia group was half that of nerve block group (2.16 versus 4.23 μg/ml; $p < 0.0001$). Ten minutes later there was no difference for plasma lidocaine concentration between groups. No patients had evidence of seizures or neurologic change during the procedure. There was no difference in patient perception of discomfort during the procedure. Patients in the topical anesthesia group recalled the intubation better than those in the nerve block group ($p = 0.004$). Both techniques for airway anesthesia were found to be similarly safe and effective and offer alternatives when patients with cervical spine disorders require awake oral fiberoptic intubation of the trachea. **Key Words:** Anesthetic drugs—Lidocaine—Neural blockade—Awake fiberoptic intubation.

Awake fiberoptic intubation of the trachea is an established technique for obtaining a secure airway in surgical patients for whom standard direct laryngoscopy is deemed difficult or unsafe. This technique has become especially valuable in neuroanesthesia. Patients with unstable cervical spines can be intubated and positioned for surgery while awake so as to follow continuous observation of neurologic status. This practice is believed to reduce risk of neurologic injury before onset of the surgical procedure (1–3).

The technical success of awake fiberoptic intuba-

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tion depends on both operator experience in performing laryngoscopy as well as adequate anesthesia of the oropharynx, larynx, and trachea. A variety of techniques have been described to obtain adequate anesthesia of the upper airway for awake intubation (4–13). These techniques can generally be grouped into two categories: (a) topical administration of local anesthetic, or (b) injections of local anesthetic at specific anatomic points to block afferent neural transmission from the oropharynx and larynx. There are possible advantages for either approach. For example, topical administration of lidocaine might cause less trauma to the oropharyngeal and laryngeal tissues than a series of injections, and the risk of accidental injection into a major blood vessel and subsequent toxic reaction can be avoided. Furthermore, topical lidocaine can still be administered to patients for whom range of motion of the jaw is limited. In contrast, nerve block techniques typically require a smaller total dose of local anesthetic, possibly decreasing the risk of a toxic reaction. Furthermore, in cooperative patients injections can be administered rapidly.

Little effort has been made to directly compare anesthetic techniques for awake endotracheal intubation in a neurosurgical population. The current study was designed to examine common variables associated with this procedure in patients with unstable cervical spines receiving either topical anesthesia or nerve blocks.

MATERIALS AND METHODS

This protocol was approved by the University of Iowa Institutional Review Board for human studies. Written informed consent was obtained from each patient.

Forty adult patients (25 male, 15 female), with normal neurologic examinations and unstable cervical spines, scheduled to undergo an operative procedure requiring endotracheal intubation, were prospectively studied. All patients received glycopyrrolate (0.3 mg i.m.) on call to the operating room. No other premedication was given, except for patients receiving pain medications: These patients were allowed to continue their scheduled doses as needed. On arrival in the operating room in the supine position, routine anesthesia monitors were placed and a radial arterial catheter was inserted. The anesthesiologist was allowed to administer midazolam (up to 4 mg i.v.) for sedation and fentanyl (up to 1 μ/kg) for pain. Doses of both drugs, however, were further restricted by judgment of the anesthesiologist with the goal that all patients would remain awake and able to follow commands throughout the procedure. Patients were then assigned by chance to one of two groups, as follows.

1. *Topical-anesthesia group* (n = 21). A nebulizer with an O_2 flow rate of 10 L/min was used to deliver up to 20 ml of 4% lidocaine (lidocaine hydrochloride, Roxane Laboratories, Inc., Columbus, OH, U.S.A.) into the oropharynx. Patients were encouraged to inhale deeply through their mouth while their nose was plugged to facilitate entrainment of nebulized lidocaine into their airway over ~10 min. Next, 4% lidocaine (3 ml) was injected through the cricothyroid membrane into the trachea.

2. *Nerve block group* (n = 19). Lidocaine spray (Xylocaine 10% oral spray, Astra Pharmaceuticals, Westborough, MA, U.S.A.) was applied directly to the tongue (50 mg total). The lingual branch of the glossopharyngeal nerve was blocked bilaterally by infiltrating the inferior aspect of the palatoglossal arch with 0.5–1.0 ml of 2% lidocaine (Xylocaine-NPS, Astra Pharmaceuticals). The superior laryngeal nerves were blocked bilaterally by infiltrating 2% lidocaine (1–2 ml) at the lateral and inferior aspect of the hyoid. Finally, 4% lidocaine (3 ml) was injected through the cricothyroid membrane into the trachea.

To maintain uniformity, airway anesthesia/sedation for all patients was provided by one of two anesthesiologists (D.R. or S.H.). After the transtracheal lidocaine injections, patients in both groups were treated identically.

The total dose of lidocaine administered was recorded. The patient's neck was covered with a towel to hide superior laryngeal nerve block injection sites. The blinded observer (D.W. or M.T.) was then brought into the operating room. Two min before onset of laryngoscopy, heart rate, mean arterial blood pressure (MAP), respiratory rate, SpO_2, and plasma lidocaine concentrations were measured (t_0). Ten minutes later (t_{10}), sampling of arterial blood for plasma lidocaine concentration was repeated.

Oral fiberoptic intubation was initiated by either

the resident physician responsible for the case, or D.R. or S.H. if that resident was unable to successfully intubate the patient within a 5-min interval. The total time required for successful intubation was recorded. During the intubation procedure, the highest MAP, heart rate, and respiratory rate were recorded as was the lowest SpO_2 value. Heart rate, MAP, SpO_2, and respiratory rate were also recorded at 2 min after positioning of the endotracheal tube in the trachea. Each patient was continuously observed for spontaneous complaint of lidocaine overdose symptoms or occurrence of convulsions.

The quality of the anesthetic during intubation was graded by an observer who was blinded to the anesthetic group assignment. The intubation grading scale was defined as follows.

0 = No coughing or gagging in response to intubation
1 = Mild coughing and/or gagging that did not hinder intubation
2 = Moderate coughing and/or gagging that interfered minimally with intubation
3 = Severe coughing and/or gagging that made intubation difficult
4 = Severe coughing and gagging that required additional local anesthesia and/or other change in technique to achieve successful intubation.

After intubation, a brief neurologic examination was performed. Subsequent anesthetic techniques were managed as required for the surgical procedure. On postoperative day 2 or 3, patients were asked to mark their degree of recall (0 = no recall of the event of intubation; 100 = total recall) and perception of discomfort (0 = no discomfort; 100 = extreme discomfort) on 100-mm visual analog scales. If the patient indicated no recall of the airway anesthesia/intubation event, perceived discomfort was not assessed.

Physiologic values were compared qualitatively so as to preserve statistical power. Total lidocaine dose and plasma lidocaine concentrations were compared between groups by the unpaired Student's *t* test. Intubation grades and visual analog scale scores were compared between groups by the Mann–Whitney *U* test. Parametric values are reported as mean ± SD. Significance was assumed if $p < 0.05$.

RESULTS

Physiologic values for the two groups are reported in Table 1. No important differences were observed between groups at any interval for heart rate, mean arterial blood pressure, respiratory rate, or SpO_2. Patients in both groups exhibited a relative hypoxemia with Pao_2 values frequently observed within the range of 65–85 mm Hg. However, the lowest SpO_2 values remained above 90% in 36 of the 40 patients. All patients remained sufficiently awake to cooperate with neurologic examination. No patient had a change in neurologic function after intubation, nor did any patient display evidence of lidocaine toxicity.

The following values are expressed as mean ± SD. Total fentanyl doses were similar between groups (topical anesthesia group = 44 ± 11 μg; nerve block group = 66 ± 33 μg). Total midazolam doses were also similar (topical anesthesia group = 2.7 ± 1.5 mg; nerve block group = 3.2 ± 0.9 mg). Although patients in the topical anesthesia group were administered a greater total dose of lidocaine (topical anesthesia group = 815 ± 208 mg; nerve block group = 349 ± 44 mg, $p < 0.0001$), plasma lidocaine concentrations in that group were the lowest at t_0 (topical anesthesia group = 2.16 ± 1.48 μg/ml; nerve block group = 4.23 ± 1.12 μg/ml, $p <$

TABLE 1. *Physiologic values recorded during awake fiberoptic intubation procedure*

	Topical anesthesia (n = 21)	Nerve block (n = 19)
2 min preintubation		
MAP (mm Hg)	98 ± 19	91 ± 14
Heart rate (beats/min)	98 ± 19	94 ± 19
Respiratory rate (breaths/min)	18 ± 4	17 ± 4
SpO_2 (%)	96 ± 4	95 ± 3
P_aO_2 (mm Hg)	72 ± 11	85 ± 25
P_aCO_2 (mm Hg)	37 ± 4	41 ± 5
Arterial pH	7.43 ± 0.02	7.41 ± 0.04
2 min postintubation		
MAP (mm Hg)	96 ± 19	93 ± 15
Heart rate (beats/min)	103 ± 19	90 ± 21
Respiratory rate (breaths/min)	16 ± 5	15 ± 4
SpO_2 (%)	99 ± 2	98 ± 2
Peak values		
MAP (mm Hg)	115 ± 20	100 ± 17
Heart rate (beats/min)	113 ± 23	101 ± 25
Respiratory rate (breaths/min)	21 ± 4	19 ± 5
Lowest SpO_2 (%)	94 ± 4	95 ± 3

MAP, mean arterial pressure. Values = mean ± SD. The topical anesthesia group received topical airway anesthesia only. The nerve block group received glossopharyngeal and superior laryngeal nerve blocks before awake fiberoptic intubation.

0.0001). At t_{10}, however, there was no difference between groups for plasma lidocaine concentration (topical anesthesia group = 3.34 ± 1.87 μg/ml; nerve block group = 4.02 ± 1.02 μg/ml; p = 0.1782) (Fig. 1).

The time required for laryngoscopy and intubation was similar between groups (topical anesthesia group = 3.2 ± 2.9 min; nerve block group = 3.2 ± 1.9 min). The quality of airway anesthesia for intubation, as judged by the blinded observer, did not differ between groups; p = 0.09. In most patients in either group, intubation was uneventful and easily performed. Four patients endured difficult intubations (grade 3 or 4) that were evenly divided between the groups (Fig. 2). Patient perception of discomfort during the intubation was not different between groups (p = 0.23). The Spearman rank correlation coefficient was computed to examine for a possible relationship between the "the quality of airway anesthesia for intubation" and "patient perception of discomfort during the intubation." A significant effect was absent (p = 0.11). Recall of the intubation was different between groups (p = 0.004). The nerve block group had less recall than did the topical anesthesia group (Fig. 3). Seven of 21 patients in the nerve block group had no recall of the intubation as opposed to 1 of 19 patients in the topical anesthesia group. The Spearman rank correlation coefficient was computed to examine for a possible relationship between plasma lidocaine at t_0 and recall of intubation. A significant effect was absent (p = 0.19).

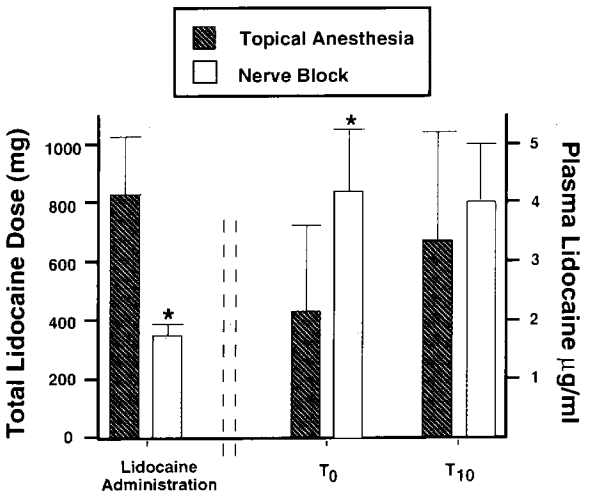

FIG. 1. Left: Total dose of lidocaine administered to provide airway anesthesia before awake fiberoptic intubation. Right: Plasma lidocaine concentrations determined at 2-min preintubation (T_0) and 10 min later (T_{10}). *p < 0.05.

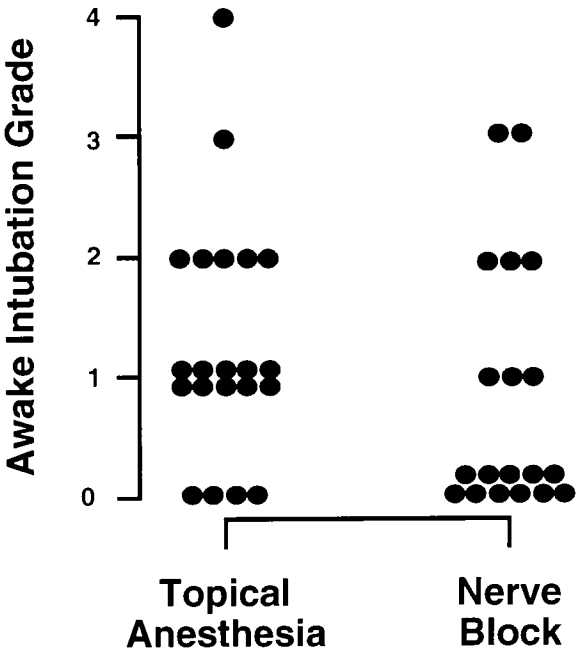

FIG. 2. Quality of airway anesthesia for awake fiberoptic intubation as graded by an observer blinded to anesthetic technique. Topical anesthesia = nebulized lidocaine; nerve block = glossopharyngeal and superior laryngeal nerve blocks. 0 = No coughing or gagging in response to intubation; 4 = severe coughing and gagging that required additional local anesthesia and/or other change in technique to achieve successful intubation.

DISCUSSION

Awake tracheal intubation performed with the aid of a fiberoptic instrument was first described by Murphy in 1967 (14). A choledochoscope was used to facilitate nasotracheal intubation in patients with difficult airways. Numerous subsequent authors have reported their techniques and experiences with fiberoptic intubation (4,7,15–17). Although awake intubation has not been prospectively compared with intubation after induction of general anesthesia in patients with cervical spine instability, it appears to offer some advantages: (a) the patient can remain in neutral position, minimizing risk of further injury; (b) the surgeon and the anesthesiologist can examine the patient's neurologic status

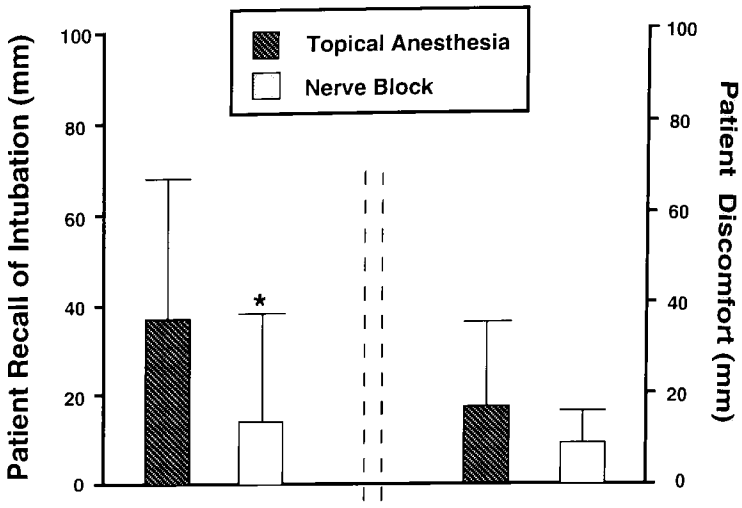

FIG. 3. Magnitude of patient recall of intubation (left; 0 = no recall of the event of intubation; 100 = total recall) and patient perception of discomfort during intubation (right; 0 = no discomfort; 100 = extreme discomfort) as determined by 100-mm visual analog scales marked by the patient on postoperative day 2 or 3. *$p < 0.05$.

after intubation and positioning; and (c) spontaneous ventilation is preserved.

The risk of causing or worsening neurological status during awake intubation in patients with cervical spine abnormalities has been shown to be minimal if the anesthesiologist is aware of the preoperative condition. In a retrospective case control study of 454 patients with cervical spine injuries, no difference in frequency of postadmission neurologic deterioration was found between the 165 patients who required intubation during their hospitalization and the remaining 289 patients who did not (18). In a different retrospective review of patients who had traumatic cervical spine injuries and who underwent intubation as a part of their operative management, only 2 of the 150 patients studied had worsening of their postoperative neurological examination (3). One of those patients had a surgical event that was thought to be responsible for the postoperative change and in the other patient neurological worsening was transient. The absence of neurologic deterioration within the 40 patients in our study is consistent with the conclusion that awake fiberoptic intubation is generally safe.

There are a multitude of methods available to obtain adequate airway anesthesia for this procedure. Most typically, such methods are developed over a series of cases, providing the individual anesthesiologist with a reliable technique that can then be repeated. To our knowledge, however, there has been no attempt to define the relative safety or efficacy for such methods in a population with cervical spine instability.

For our study, two anesthetic techniques were chosen. Although anesthesiologists may use elements of both techniques, for the purpose of this study, attempts were made to maintain the techniques as differently as possible. Furthermore, to control for differences between practitioners, all anesthesia for the upper airway was provided by two investigators who attempted to make the specific techniques the same for all patients in respective groups. Finally, intubations were carried out by residents at various levels of training and there was no attempt to control for operator experience within the first 5 min of bronchoscopy. Instead, two techniques were chosen that were believed capable of providing optimal intubating conditions for any operator. This proved successful in that only 1 of 40 intubations was considered a failure of the protocol.

There has been at least one study in the thoracic medicine literature that compared anesthesia techniques for bronchoscopy (13). In that work, both patients and bronchoscopists preferred a simple transtracheal injection of lidocaine over either nebulized lidocaine or lidocaine administered via the suction port of the bronchoscopee. However, that study was performed in an unblinded fashion and the doses of lidocaine administered were small. For example, in the group receiving the aerosol, only 4 ml of 4% lidocaine were administered. Coughing was frequent throughout the procedure. In contrast, during awake intubation for the patient with cervical spine instability, the risk of injury from coughing or gagging is thought to be substantial and thus

more lidocaine is likely to be administered to prevent such events from occurring.

Lidocaine seizures remain a concern during awake intubation, although the frequency of such events as reported in the literature is rare (19). A large difference between the two anesthetic techniques was the total dose of lidocaine administered. Given the substantially greater amount of lidocaine given to the topical anesthesia group, one would predict greater resultant plasma lidocaine concentrations. This was not the case within at least the first 10 min after lidocaine administration was completed. Apparently, more of the topically applied lidocaine underwent delayed absorption into the bloodstream, or was swallowed resulting in greater hepatic clearance, than lidocaine injected directly into tissue.

An unexpected difference observed between the two techniques was the degree of patient recall. Patients in the topical anesthesia group had greater recall of the intubation procedure despite similar doses of administered midazolam. It is possible that unrecorded differences in *timing* of the midazolam may have resulted in differences in recall. We theorized that the greater plasma lidocaine concentrations measured in the nerve block group augmented the amnestic properties of midazolam. However, there was no correlation between recall and preintubation plasma lidocaine concentration, leaving the cause for this observation unknown.

Given the results of this study and the relatively small sample size employed, the following conclusions may be drawn. First, patients with unstable cervical spines may safely and successfully undergo awake intubation of the trachea by either topically applied lidocaine or specific nerve blocks. Second, although upper airway anesthesia achieved by topically applied lidocaine is associated with large doses of the drug, plasma levels achieved during laryngoscopy and intubation remain within a safe range. Finally, patient experience is acceptable and not remarkably different with either technique, allowing the anesthesiologist a choice for specific patient circumstances.

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