Relationship of tonsil size on an airway blockage maneuver in children during sedation

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Abstract

A previous report suggested that airway compromise without self-correction may occur in pediatric dental patients sedated with chloral hydrate (CH) and nitrous oxide (N_2O) and may be interpreted as "deep" sedation.[1] The purpose of this institutionally approved study was to determine 1) the association between the size of the tonsils and 2) the degree of expired carbon dioxide (CO_2) and oxygen saturation (SaO_2) changes to simulated airway obstruction using the Moore head-tilt maneuver for 30 sec or less. Thirty healthy children (ASA I), aged 22–40 months, were evaluated for tonsil size and sedated with CH (50 mg/kg) and hydroxyzine (2 mg/kg) and supplemented with N_2O. Pulse oximetry and capnography were used to monitor the child. During the restorative phase when the patient appeared asleep, the head was rolled forward with the chin touching the chest for a period of 30 sec. Changes in SaO_2 and CO_2 waveform were observed during this period. The results indicated that seven children who had enlarged tonsils had blocked airways (as determined by capnography) lasting approximately 15 sec. The remaining children did not have enlarged tonsils and continued to exchange air appropriately. O_2 levels did not change during this period. The results suggest that the likelihood of airway blockage increases with enlarged tonsils. In children without airway blockage, ventilation occurs unimpeded, and attempts to readjust the head may not occur. The association between airway blockage and patient responsiveness is discussed in relation to sedation levels. (Pediatr Dent 19:277–81, 1997)

Conscious sedation is defined as a minimally depressed level of consciousness that retains a patient's ability to continuously and independently maintain a patent airway and respond appropriately to physical stimulation and/or verbal command.[2] Guidelines on sedation for children include the clinically recognized category of "conscious" sedation.[2,3] For purposes of this paper, this definition should be retained as a conceptual reference.

Moore et al.,[1] evaluated the level of consciousness during sedations in children by assessing the patient's ability to maintain a patent airway. Airway blockage was attempted by positioning the child's head with the chin touching the chest. The length of time for the maneuver was not reported. They reported four of 15 patients sedated with 60 mg/kg chloral hydrate (CH) plus 50% nitrous oxide/oxygen (N_2O) failed to readjust the head as a result of the maneuver. Although they indicated blockage was confirmed periodically via a stethoscope, no data were available to suggest those who failed to respond were assessed with a stethoscope.

They indicated that "normally" a child will respond immediately by repositioning the head. It was not clear if "normally" in the context of their statement referred to a situation wherein the child is not sedated or, alternatively, to conditions associated with sedation. An unsedated and uncooperative young child may be expected to react quickly and readjust the head because of the perceived irritation the maneuver caused the child. However, under conditions of sedation, failure to respond to the maneuver apparently is interpreted as indicating "deep" sedation in which airway reflexes are potentially compromised. An alternative interpretation is that the patient is sufficiently unreactive, not unlike a naturally sleeping child, and is not irritated by the maneuver. Furthermore, the airway may not be fully blocked and ventilation is possible.

Iwasaki et al.[4] evaluated the use of capnography in conjunction with pulse oximetry for monitoring children during conscious sedation for dental treatment. They also used the Moore head-tilt maneuver to assess airway patency in which a response was expected "immediately". The analysis of data obtained from monitoring 10 patients sedated only with CH (75 mg/kg) revealed that specific CO_2 concentration values were not predictive of subsequent oxyhemoglobin desaturations and that capnography was very accurate in detecting complete obstruction of the airway. Only one patient failed to respond to the head-tilt maneuver, and apparently capnography confirmed blockage. Again, the duration of time involved in the head maneuver was not stated.

During a study to evaluate patient behavior, Houpt et al.[5] also monitored respiration in 21 children sedated with either CH 50 mg/kg and 50% N_2O or 75 mg/kg and 40% N_2O. One sensor was attached to the chest to monitor chest movements and a second sensor was attached to the inhalation unit to monitor gas exchange. The monitor on the inhalation unit was used to detect possible obstructions that would restrict respiration. They reported that exchange was reduced, although chest movements continued unchanged. They attributed this to a partial airway blockage during the operative procedure (e.g., rubber dam placement, seating stainless steel crowns). The significance of this transitory partial blockage is clinically important and suggestive of a need for more frequent quantitative monitoring.

The purpose of this study was to determine 1) the association between the size of the tonsils and 2) the degree of CO_2 and SaO_2 changes to simulated airway obstruction using the Moore head-tilt maneuver for 30 sec or less.

Methods and materials

Thirty children, ages 22–48 months, participated in this institutionally approved study. All children were ASA Class I, not taking any medications and required sedation for completion of operative dentistry. Only children who exhibited negative or definitely negative behavior, according to the Frankl Behavior Rating Scale[6], were included. Pediatric dental staff and residents were trained in the use of the Frankl Scale; however, no formal calibration was done. Exclusion criteria included children with tonsils exceeding two-thirds of the visible airway and children with a history of allergy or adverse reaction to any of the medications.

CH (50 mg/kg) and hydroxyzine (2 mg/kg), both administered orally, plus N_2O (40–50%) supplementation were used in the study. Physiologic monitoring was carried out with the following equipment: Critikon Dinamap™ vital signs monitor, 1846SX (blood pressure); Nellcor™ pulse oximeter and printer, model N-100 and N-9000, respectively (heart rate and peripheral SaO_2); Datex™ carbon dioxide monitor, model 223 (CO_2), and associated Datex™ computer software program. The Porter MXR™ N_2O delivery system was used.

Upon patient arrival, the sole operator in the study (DF) verified NPO status, evaluated general health status, and obtained parental consent. The adequacy of the airway was evaluated by the operator, and tonsil size was graded as follows: 0 = no visible tonsils; 1 = visible tonsils up to but not exceeding one-third of the visible airway; 2 = visible tonsils greater than one-third but not exceeding two-thirds of the visible airway.

The child was weighed and taken to the dental operatory for baseline physiologic values (blood pressure, heart rate, SaO_2, and CO_2). The appropriate dose of CH and hydroxyzine was administered and after a 45- to 60- min latency period, the child was brought to the treatment room. The pulse oximeter was affixed to the child's right toe, the blood pressure cuff was placed on the right arm, and a precordial stethoscope was placed to monitor breath sounds. Prior to placing the nasal hood for N_2O, the nasal canula for side-stream capnography was placed in the right naris.

For consistency, all patients were wrapped in the Papoose Board® (Olympic Medical Group, Seattle, WA) prior to initiating treatment. The operator initiated and titrated N_2O, adjusting the concentration of N_2O up to but not exceeding 50%. The concentration was reduced during the operative procedure to 40% if adequate sedation was maintained.

Physiological parameters were recorded throughout the treatment session. The operator determined what was perceived as the patient's deepest level of sedation based on prolonged quietness or sleep during the first 30 min following the initiation of treatment. The operator then confirmed that SaO_2 was 98% or greater, CO_2 was consistent with values obtained during the operative procedure, and the patient's airway was not com-

Table 1. Descriptive statistics of sample population

Variable	*Statistic*
Total Sedations	30
Age	22–48 months (mean ± SD = 35 ± 7)
Male:Female Ratio	16:14
Weight	11.0–18.5 kg (mean ± SD = 14 ± 2)

Table 2. Frequency distribution of level and effectiveness of sedations

Level of Sedation	*Count*
No change	0 (0.0%)
Slept/responsive to stimuli	16 (53.3%)
Slept/could be awaken	14 (46.7%)
Nonresponsive	0 (0.0%)
Effectiveness of Sedation	*Count*
Excellent	20 (66.7%)
Good	9 (30.0%)
Fair	1 (3.3%)
Poor	0 (0.0)

Table 3. Tonsil size and frequency distribution during head roll

Tonsil Size	*N*	*Airway Patent with Head Roll*	*Airway Obstruction with Head Roll*
None Visible	21	21	0
Visible to 1/3 Airway	7	2	5
Visible 1/3–2/3 Airway	2	0	2
Total	30	23	7*

* Chi-square = 8.533; $P < 0.005$.

TABLE 4. MEAN SaO_2 AND CO_2 VALUES FOR TIME PERIODS DURING THE HEAD ROLL

Variable	*Time*							
SaO_2	*Base I*	*5 sec*	*10 sec*	*15 sec*	*20 sec*	*25 sec*	*30 sec*	*Base II*
No Tonsils	99.4 ± 1.2•	99.5 ± 1.2	99.4 ± 1.4	99.4 ± 1.4	99.3 ± 1.5	99.3 ± 1.4	99.3 ± 1.4	99.3 ± 1.5
Tonsils	99.7 ± 0.5	99.6 ± 0.5	99.5 ± 0.5	99.6 ± 0.5	99.6 ± 0.5	99.6 ± 0.5	99.6 ± 0.5	99.4 ± 0.5
CO_2								
No Tonsils	39.0 ± 5.0	37.5 ± 7.5	37.5 ± 12.5	39.8 ± 10.8	40.1 ± 6.8	42.1 ± 5.2	43.6 ± 4.0	41.0 ± 6.5
Tonsils	42.2 ± 4.0	42.7 ± 5.7	42.9 ± 5.2	26.6 ± 19.5	10.2 ± 13.5	14.4 ± 16.4	17.2 ± 20.9	39.2 ± 5.3

• Mean ± SD.

promised. The operator gently rolled the patient's head forward until the chin touched the chest. For patient safety and in compliance with human subjects committee guidance, this period did not exceed 30 sec. SaO_2 and CO_2 were recorded every 5 sec during the 30-sec interval by a dental assistant (blinded to tonsil size). Any self-attempts to correct the airway were not prevented by the operator. The head was then returned to a resting position and the operative treatment completed. Following the appointment, the quality and depth of the sedation and any adverse side effects were noted by the operator.

Descriptive statistics were used to characterize the age and sex of the sample population. Differences in SaO_2 and CO_2 as a function of dental procedures were determined using a repeated measures analysis of variance. Additionally, a repeated measures analysis of variance was performed to determine significance for SaO_2 and CO_2 as a function of tonsil size over time. Chi-square analysis was used to determine the significance of frequency of presence or absence of airway blockage during the head tilt.

TABLE 5. REPEATED MEASURES ANOVA OF SaO_2 AND CO_2 AS A FUNCTION OF TONSIL SIZE

Factor	*F*	*P*
SaO_2 between (tonsil size)	0.13	NS
SaO_2 within (time)	1.26	NS
SaO_2 (tonsil size by time)	1.00	NS
CO_2 between (tonsils)	28.86•	0.001
CO_2 within (time)	12.91•	0.001
CO_2 interaction (tonsil size by time)	19.77•	0.001

• Significant values ($P < 0.005$).

Results

The data collected from the 30 sedation visits consisted of a sample population of 16 males and 14 females ranging in age from 22 to 48 months (Table 1). The concentration of N_2O ranged from 40 to 50% (mean = 47.57%). Table 2 shows the frequency distributions for the level and effectiveness of the sedations. A majority of the patients slept, but were responsive to stimuli and most were rated as good to excellent sedations.

Nine patients (30%) were noted preoperatively to have visibly enlarged tonsils varying in size (Table 3). The capnograph identified airway occlusion in seven of 30 patients (23.3%) occurring between 15 and 20 sec into the head roll. The chi-square test determined this to be statistically significant ($P < 0.005$). The seven patients who obstructed during the head roll maneuver all had enlarged tonsils. Table 4 presents the mean SaO_2 and mean CO_2 values during the head roll procedure with patients divided into two groups based on the presence or absence of tonsils. A repeated measures ANOVA determined that the presence of tonsils does not significantly affect SaO_2 during the head roll (Table 5). The presence of tonsils did, however, significantly decrease the mean CO_2 values. Mean SaO_2 and CO_2 also were evaluated as a function of operative procedure (Table 6). No statistically significant differences were noted when comparing patients without visible tonsils to those with visible tonsils for any procedure.

Discussion

It has been suggested that a young patient's responsiveness and immediate head self-adjustment during sedation reflects a "conscious" level of interaction because such an overt response seemingly would imply the airway patency had been compromised.[1] We noted airway blockage in seven children who had enlarged tonsils and who made no attempt to self-adjust the head during the 30-sec period.

The results of our study are similar to those of others in that some patients failed to readjust their head.[1,4] However, the additional variables of tonsil size and duration of the head maneuver may offer alternative reasons for the failure of head adjustment, which has been interpreted solely as "deep" sedation. Airway blockage, as identified by capnography in this study, was found to occur exclusively in children with visibly enlarged tonsils. Thus, enlarged tonsils appear to increase

TABLE 6. MEAN SaO_2 AND CO_2 FOR THE TIME PERIOD DURING THE OPERATIVE PROCEDURE

Variable					*Time*				
SaO_2	*Base*	*Topical*	*Local*	*RD*	*Begin TX*	*TX 5 min*	*TX 10 min*	*TX 15 min*	*TX End*
No tonsils	98.6 ± 1.5*	99.5 ± .09	99.4 ± 1.0	99.3 ± 1.3	99.5 ± 0.8	99.5 ± 0.7	99.6 ± 0.8	99.2 ± 1.6	99.1 ± 1.5
Tonsils	98.7 ± 1.2	99.3 ± 0.9	99.3 ± 1.2	99.2 ± 0.8	99.8 ± 1.6	99.3 ± 1.8	99.3 ± 1.2	99.0 ± 1.2	99.2 ± 1.6
CO_2									
No tonsils	37.7 ± 5.2	35.5 ± 5.4	33.8 ± 8.3	35.5 ± 8.9	43.1 ± 9.6	35.3 ± 9.9	37.1 ± 7.9	36.3 ± 8.0	34.4 ± 9.0
Tonsils	37.7 ± 4.7	38.2 ± 4.4	36.3 ± 6.1	37.4 ± 5.1	38.0 ± 6.7	37.0 ± 6.9	37.0 ± 7.8	37.2 ± 5.1	35.8 ± 5.0

* Mean ± SD.

the probability of airway compromise during the head roll procedure. Of the nine children who had tonsils spanning one-third to two-thirds of the airway, seven demonstrated airway obstruction during the head roll in this study. The time period for blockage, if it occurred, was minimal (approximately 15–20 seconds) and may not have been sufficient to cause head self-adjustment.

In the children without detectable tonsils, and in two with smaller tonsils, unimpeded breathing occurred despite an attempt to block their airway by the head-tilt maneuver for a period of 30 sec. The data from this study strongly suggest that in the absence of enlarged tonsils, sedated children can maintain their airways independently, at least for a brief period of time. This finding would be consistent with the anecdotal and frequently noted observation that young children sleep in car seats with the head resting on the chest. Children with large tonsils who ride in car seats must, at some point in time, re-adjust the airway and such may have been the case in this study should the period of observation have exceeded 30 sec.

Thus, if a child fails to immediately correct the airway because either it is not obstructed during the maneuver or the duration of the maneuver was too limited to provoke a response, confusion may result about the interpretation regarding the appropriate clinical classification as either "conscious" or "deep" sedation. One might argue that the anxiety of the children is minimized and children are sleeping restfully. It should be noted that very young children who *need* sedation for clinical procedures, and are either awake or minimally drowsy, naturally will resist rolling of the head forward immediately regardless of whether or not their airway is blocked.

One may challenge the idea that a lack of response to this maneuver reflects pharmacologically induced loss of protective reflexes. Because of the limitation imposed by the period of attempted airway block in this study and the lack of a desaturation episode during that period, a lack of response cannot be definitively categorized as "deep" sedation or loss of protective reflexes (after a longer period, they may have responded appropriately). The child may simply be resting peacefully while exchanging air. Clearly such a maneuver as used in this study remains questionable as a method to discriminate among clinical states.

The influence of tonsils on airway patency has been reported previously. Through clinical and radiographic examination, Brouillette et al.[7] identified enlarged tonsils and/or adenoids as a causative factor in 14 of 22 infants and children diagnosed with obstructive sleep apnea. The prolonged partial airway obstruction during sleep resulted in episodes of hypercarbia and/or hypoxia. Air exchanged was noted to improve upon removal of tonsillar and/or adenoidal tissue.

Previous studies also have suggested the possible effects of CH and enlarged tonsils on airway compromise. Hershenson et al.[8] described an episode of upper airway obstruction with a near-fatal respiratory arrest after administration of two doses of CH (55 mg/kg) in a 3-year-old patient with a history of obstructed sleep apnea due to tonsillar hypertrophy.

Furthermore, Biban et al.[9] reported two cases of respiratory failure in two 24-month-old children with suspected obstructive sleep apnea following administration of CH (80 mg/kg). Again, adenotonsillar hypertrophy was considered a possible factor causing the obstructive episodes.

A notable finding in this study was that, despite a lack of exchange of air in patients with documented airway blockage, the SaO_2 did not significantly change during the duration of the head rolls. It is likely that the patient was indeed well oxygenated during the brief 30-sec period of the head roll. It is possible that corrective head movements may have been observed eventually. This suggests that the oximeter was not as sensitive as the capnograph in detecting early airway compromise. This finding supports that of others.[10, 11] Also, each of the seven patients continued to attempt to exchange air during the head roll maneuver. This was characterized by vigorous rocking movements of the chest during the 30-sec period as seen by others.[5]

The presence or absence of tonsils appears to be clinically significant. The potential of airway compromise appears to increase in children who have enlarged tonsillar tissue. It is interesting that only one episode of desaturation was noted during the entire study, in a patient with tonsils encompassing two-thirds of the visible airway.

The results of this study stress the importance of a proper preclinical examination. Any candidate for conscious sedation should be evaluated for enlarged tonsils prior to treatment. If large tonsils are present, perhaps alternative treatment options should be considered or the airway monitored by capnography if the child falls asleep.

The suggestion has been made that the depth of sedation involving CH may be increased from a level of conscious to deep sedation if used in combination with N_2O.[1] This is of particular significance because current AAP guidelines[3] restrict the use of N_2O with other sedative drugs, heavily based on the findings of Moore et al.[1] The findings in this study suggest that such conclusions may be premature and the guidelines should be less restrictive until additional scientific evidence is available. Failure to immediately self-adjust an airway to the head roll maneuver in a sedated child may not be considered, in and of itself, consistent with deep sedation if the child continues to exchange air appropriately. Possibly the interpretative problem lies in the definitions of conscious and deep sedation.

The results of the head roll maneuver should be interpreted with caution. A 30-sec interval may not have been sufficient to assess airway blockage. If the head position was maintained beyond 30 sec, the patients eventually may have obstructed as a result of tiring from the physical work of breathing with their head in the unusual position. However, it should be pointed out that none of the 21 patients without visible tonsils gave any indication that they were laboring in their breathing efforts at any time.

Conclusions

Based on the findings of this study, the following conclusion can be made:

1. For a short period of time, sedated children can maintain their airway independently when the head is rolled forward with the chin touching the chest. The ability is potentially compromised when performed in sedated children with prominent tonsils.
2. Capnography detects early airway compromise in the sedated patient more readily than does pulse oximetry.
3. There is a statistically significant decrease in CO_2 during a period in which the head is rolled forward with the chin touching the chest in children with enlarged tonsils than in those without.

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