Anesthesiology 2008; 108:216–24

Desflurane but Not Sevoflurane Impairs Airway and Respiratory Tissue Mechanics in Children with Susceptible Airways

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Background: **Although sevoflurane and desflurane exert bronchoactive effects, their impact on the airway and respiratory tissue mechanics have not been systematically compared in children, especially in those with airway susceptibility (AS). The aim of this study was to assess airway and respiratory tissue mechanics in children with and without AS during sevoflurane and desflurane anesthesia.**

Methods: **Respiratory system impedance was measured in healthy control children (group C, n = 20) and in those with AS (group AS, n = 20). Respiratory system impedance was determined during propofol anesthesia and during inhalation of sevoflurane and desflurane 1 minimum alveolar concentration in random order. Airway resistance, tissue damping, and elastance were determined from the respiratory system impedance spectra by model fitting.**

Results: **Children in group AS exhibited significantly higher respiratory impedance parameters compared with those in group C. Sevoflurane slightly decreased airway resistance (−7.0 ± 1.5% *vs.* −4.8 ± 2.4% in groups C and AS, respectively) in both groups. In contrast, desflurane caused elevations in airway resistance and tissue mechanical parameters, with markedly enhanced airway narrowing in children with AS (18.2 ± 2.8% *vs.* 53.9 ± 5%; $P < 0.001$ for airway resistance in groups C and AS, respectively). Neither the order of drug administration nor the time after the establishment of their steady state concentrations affected these findings.**

Conclusions: **These results emphasized the deleterious effects of desflurane on the airways, particularly in children with susceptible airways in contrast with the consistent beneficial effects of sevoflurane, questioning the use of desflurane in children with AS.**

RESPIRATORY adverse events are one of the major causes of morbidity and mortality during pediatric anesthesia.[1,2] Among the risk factors that increase perioperative respiratory complications, bronchial hyperreactivity (BHR) is the most frequent underlying pathophysiologic condition encountered in pediatric anesthesia. BHR is the common denominator of many pulmonary conditions in children, such as asthma, upper respiratory tract infection,[2–4] cystic fibrosis, bronchopulmonary dysplasia, and passive smoking.[5] These diseases have a high prevalence in routine pediatric anesthesia practice,[6,7] and all lead to high airway susceptibility (AS) to different stimuli. Therefore, it is crucial for the pediatric anesthesiologist to optimize the anesthetic management for these children to improve their perioperative safety.

During the past decade, halothane has been gradually replaced by sevoflurane and desflurane because of their lower coefficients of blood solubility and decreased side effects. Nevertheless, there are conflicting data regarding the potential beneficial effect of these agents to prevent and/or reverse lung constriction.[8–14] While the majority of previous studies demonstrate that sevoflurane exerts a protecting effect against bronchoconstriction,[9,11–15] respiratory resistance also increases under sevoflurane after induction of anesthesia[16] and after tracheal intubation.[17] Desflurane is more controversial: It reduces bronchoconstriction[8,14,18–21] and has no effect on basal[22] and elevated airway tone,[9] but it does irritate the airways as manifested by an elevated respiratory resistance.[8,10] Analysis of previous investigations suggests that sevoflurane elicits beneficial changes in lung function in patients or experimental animals with normal airways,[11–13,17,23] whereas desflurane[9,18–21,23] seems to elicit the most severe detrimental effects in allergically sensitized animals[10] and in patients with BHR.[9,17] The aim of the current study was to compare the effects of sevoflurane and desflurane on respiratory mechanics in children with normal and susceptible airways by evaluating airway resistance and respiratory tissue mechanics.

Materials and Methods

Anesthetic Management

After approval by our institutional ethics committee (University Hospitals of Geneva, Geneva, Switzerland) and obtaining parental written informed consent, 40 children aged 1–6 yr with and without AS who were undergoing elective surgery with tracheal intubation were enrolled in the study. The control group of children (n = 20) had healthy lungs with no history of cardiopulmonary disease, including respiratory tract infections in the past 4 weeks before surgery. The children of the AS group (n = 20) were categorized as having AS defined by doctor-diagnosed asthma (n = 10) or a recent upper respiratory tract infection (n = 10) in the past 2 weeks before anesthesia. Among the 10 asthmatic-diagnosed children, 4 received daily salbutamol treatment that was administered the morning of surgery. The 6

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Received from the Pediatric Anesthesia Unit, Geneva Children's Hospital, University Hospitals of Geneva, Geneva, Switzerland. Submitted for publication March 14, 2007. Accepted for publication October 10, 2007. Supported by the Swiss National Science Foundation (SNSF 105828/1), Bern, Switzerland. Dr. Petak is supported by the Bolyai János research fellowship.

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remaining asthmatic children had only intermittent salbutamol therapy and did not receive any preoperative bronchodilators. In addition, none of them were treated with routine inhalation steroid therapy. The two main groups of children were similar in age, body weight, and height.

According to our routine clinical practice, all patients received oral midazolam (0.35 mg/kg) for premedication 10–15 min before anesthesia. Anesthesia was induced *via* inhalation of sevoflurane (incremental doses up to 8%). As soon as intravenous access was achieved, sevoflurane was discontinued, and a bolus of 2 mg/kg intravenous propofol was administered, followed by a propofol infusion (12 $mg \cdot kg^{-1} \cdot h^{-1}$ for the first 10 min of general anesthesia, 9 $mg \cdot kg^{-1} \cdot h^{-1}$ for another 10 min, and then 6 $mg \cdot kg^{-1} \cdot h^{-1}$).[24] Before tracheal intubation with a cuffed endotracheal tube (Mircocuff-Heidelberg, Weinheim, Germany), all patients received atracurium (0.5 mg/kg) and were manually ventilated for 3–4 min with 100% oxygen. All patients received sufentanil or fentanyl as an analgesic agent in a dose suitable to the surgery performed.

After tracheal intubation, patients were mechanically ventilated (Draeger Primus; Luebeck, Germany) using a pressure-controlled mode with an end-expiratory pressure of 5 cm H_2O, targeting an end-tidal carbon dioxide of 5.5 kPa while the fraction of inspired oxygen was set to 0.5 in a mixture of air. These ventilatory parameters were maintained throughout the study period. Heart rate, oxygen saturation, and blood pressure were monitored continuously in all patients.

Measurement of Airway and Respiratory Tissue Mechanics

The low-frequency forced oscillatory technique that was used in the current study has been previously described.[25,26] Briefly, the oscillatory signal to measure the input impedance of the respiratory system (Zrs) was introduced into the trachea during short apneic periods (8 s) interposed during mechanical ventilation by connecting the tracheal cannula from the respirator to a loudspeaker-in-box system at end-expiration. The loudspeaker generated a small-amplitude pseudo-random signal with frequency components between 0.5 and 21 Hz. To exclude the effect of the endotracheal tube, tracheal pressure was sensed *via* lateral holes on the tip of a small-diameter plastic catheter, positioned 1–2 cm beyond the distal end of the endotracheal tube, attached to a miniature pressure transducer (model 33NA002D; ICSensors, Malpitas, CA). Central flow was detected by a screen pneumotachograph attached to an identical type of differential pressure transducer. Tracheal pressure and flow signals were low-pass filtered at 50 Hz and sampled with an analog–digital board of a computer at a rate of 128 Hz. Fast Fourier transformation with 4-s time windows and 95% overlapping was used to calculate Zrs. To separate the airway and tissue mechanics, a model[27] containing a frequency-independent (newtonian) resistance (Rn) and inertance (I) in series with a constant-phase tissue compartment characterized by damping (G) and elastance (H) was fitted to the Zrs spectra by minimizing the differences between the measured and modeled impedance values.

The parameters Rn and I can be attributed to the airways (being the contributions by the chest wall), whereas G and H represent the viscous (resistive) and elastic properties, respectively, of the total respiratory tissues.[26,27] Impedance data at frequencies coinciding with the heart rate and its harmonics were omitted from the model fitting if cardiac activity caused a low signal-to-noise ratio at these frequency components.

Measurement Protocol

Before the first set of Zrs measurements, it was assured that there was no further end-expiratory sevoflurane for at least 2 min, as measured by the anesthetic workstation (Draeger Primus). Then, a lung recruitment maneuver to total lung capacity was performed to standardize the volume history by manually elevating the peak inspiratory pressure to 40 cm H_2O for 10 consecutive breaths. Next, the first set of four Zrs measurements was performed under propofol anesthesia before switching the anesthetic maintenance to 1 minimum alveolar concentration (MAC) (age controlled as calculated by the anesthetic workstation according to the formula of Mapleson[28] based on age in years [$MAC = MAC\,40 \times 10^{(-0.00269 \times (age - 40))}$]) of either desflurane or sevoflurane, in random order. After the establishment of a steady state concentration of the first volatile anesthetic agent, a 3-min period was allowed for the agent to exert its effect and a second series of four Zrs measurements were performed. Zrs recordings were repeated 8 and 13 min after the establishment of a steady state of 1 MAC. The first volatile anesthetic agent was then discontinued, and the maintenance of anesthesia was switched to the second volatile agent. After ensuring the clearance of the first anesthetic agent and the establishment of a steady state concentration with the second volatile anesthetic at 1 MAC, sets of Zrs measurements were performed at 3, 8, and 13 min, similar to the first phase.

Statistics

Estimation of the sample size was performed using the nQuery Advisor 4.0 software (Statistical Solutions Ltd., Boston, MA). Based on our previous investigations in children,[25] a sample size of 20 in each group will have 95% power to detect a difference in means between 6.0 and 7.20 cm $H_2O \cdot s/l$ (20% difference), assuming that the common SD is 1.0 cm $H_2O \cdot s/l$ using a two-group *t* test with a 0.050 two-sided significance level. Blocked randomization was obtained using a computer-generated

Table 1. Demographic Data of All Children

	Children with Normal Lungs			Children with Airway Susceptibility		
	All	Sevo–Des	Des–Sevo	All	Sevo–Des	Des–Sevo
Age, mo	39 (18.0)	39 (17.5)	39 (19.5)	39 (14.0)	40 (16.5)	39 (13)
Weight, kg	14 (4.2)	14 (4.3)	14 (4.3)	15 (3.7)	15 (4.8)	15 (2.9)
Height, cm	98 (10.9)	98 (11.8)	97 (10.4)	98 (9.4)	100 (10.4)	97 (9.3)
Sex, M:F	11:9	6:4	5:5	12:8	7:3	5:5

The data of all children are divided into the two groups (with and without airway susceptibility) and the two subgroups depending on the order of the agents administered. Values are mean (SD).

Des = desflurane; sevo = sevoflurane.

random number, and randomization was concealed until clinical procedures were initiated.

Data were successfully collected in all patients (including demographic and oscillatory parameters), with no missing values in the statistical analysis. Because the procedural data proved to be normally distributed as analyzed by the Shapiro-Wilk test, data are reported as mean ± SE. The demographic differences between the protocol groups were assessed by using *t* tests for the continuous variables (age, weight, height) and chi-square test for categorical data (sex). Two-way repeated-measures analysis of variance using a linear mixed model was used to test significance with two within-subject factors: the time and the group assignment of the children. For pairwise comparisons, 95% confidence intervals for the differences were computed by taking into account the significant interactions between the factors. The relative changes in the mechanical parameters were compared by using one-way analysis of variance tests. The Student-Newman-Keuls test was used for *post hoc* comparisons. $P < 0.05$ was considered significant. SigmaStat (Systat Software Inc., Richmond, CA) and SAS (SAS Institute Inc., Cary, NC) statistical software packages were used for the tests.

Results

The measurement protocol was successfully completed in all 40 children enrolled in the study. Demographic data are depicted in table 1. There was no difference in any of the demographic parameters between the protocol groups.

Airway and respiratory tissue parameters are shown in figure 1 for the children with normal and hyperreactive airways during propofol anesthesia and 13 min after inhalations of desflurane and sevoflurane. At the initial phase of the protocol when the children were anesthetized with propofol, the parameters Rn, G, and H were significantly elevated in the children with AS. Two-way analysis of variance revealed that the anesthetic agent (propofol, sevoflurane, desflurane) had statistically significant effects on the levels of the mechanical parameters ($P < 0.001$ for all), with no significant interaction between the anesthetic agent and the order of their administration. However, the presence of AS statistically significantly affected all of the respiratory mechanical parameters ($P < 0.001$), with statistically significant interactions between the presence of AS and the anesthetic agent ($P < 0.001$). Independent of the presence of AS, administration of sevoflurane had no statistically significant effects on the mechanical parameters relative to their levels obtained during propofol anesthesia if the order of anesthetic drugs was distinguished. In contrast, desflurane induced marked and statistically significant elevations in all respiratory mechanical parameters, particularly in Rn, with greater increases in the children with BHR. Because neither the order of the administration of the anesthetic volatile agents ($P = 0.55$, $P = 0.93$, $P = 0.97$, and $P = 0.97$ for Rn, I, G, and H, respectively) nor the time elapsed after their administration had an effect on the magnitude of their action on respiratory mechanics, the results obtained from each group for the two inhalation agents were pooled and are presented in figure 2. These pooled data exhibit minor but statistically significant beneficial effects of sevoflurane when compared with propofol; in contrast, desflurane induced marked and statistically significant elevation in airway and respiratory tissue parameters, with substantially greater effects in children with AS. Analysis of variance revealed significant time effect ($P < 0.001$ for all parameters except I with sevoflurane, where $P = 0.25$) and that the presence of AS had significant effects on the levels of the mechanical parameters ($P < 0.001$). Furthermore, there was a statistically significant interaction between the factors time and the presence of AS for Rn ($P < 0.001$ for both sevoflurane and desflurane) and G ($P = 0.006$ and $P = 0.012$ for sevoflurane and desflurane, respectively), whereas the interaction was significant for I only with desflurane ($P < 0.001$), and no significant interaction between these factors was observed for H.

The changes in the airway and respiratory tissue parameters at 13 min after the administration of the volatile anesthetics relative to their baseline levels (propofol administration) are shown in figure 3. In both groups of children, minor but statistically significant decreases were observed in the mechanical parameters during

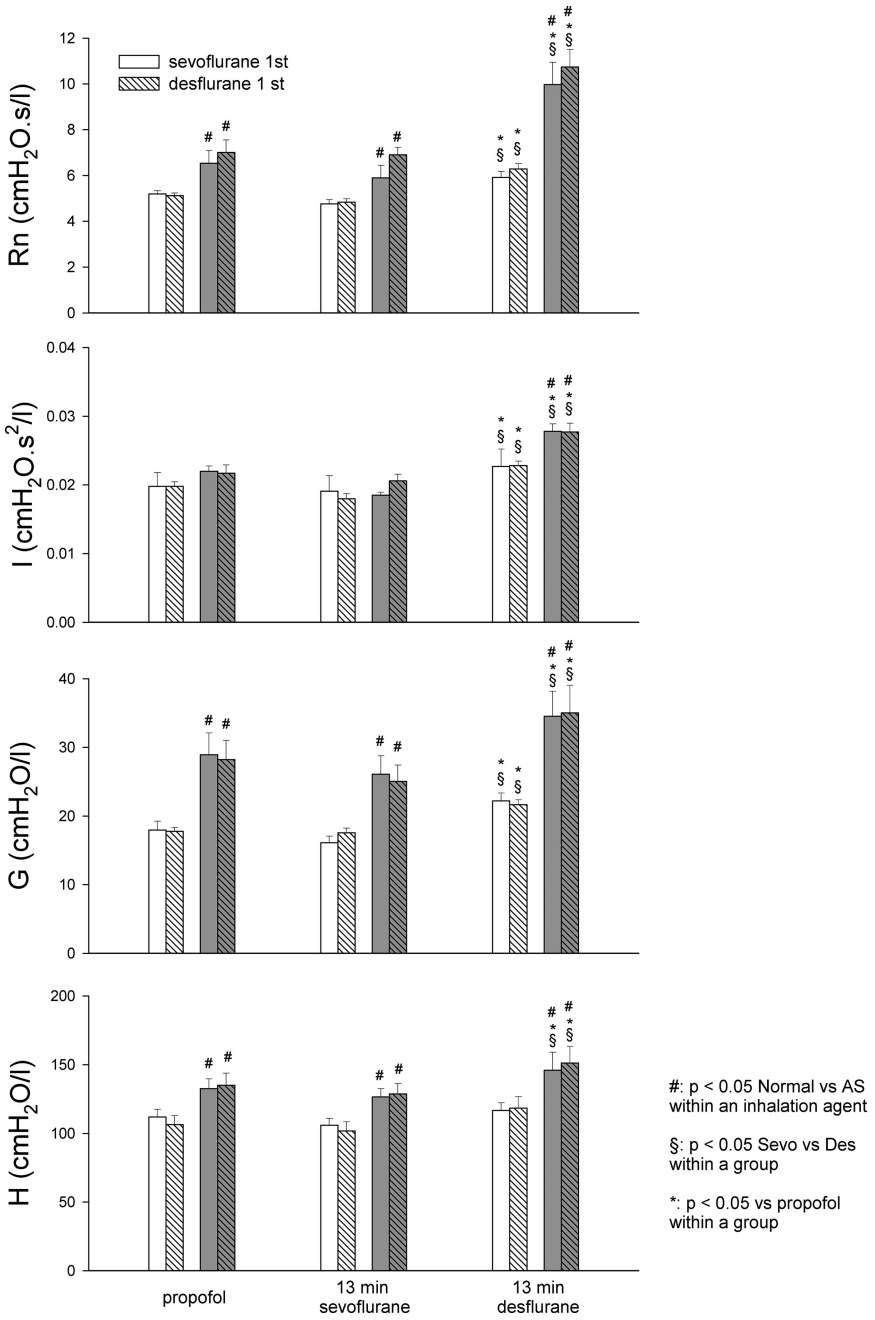

Fig. 1. Airway resistance (Rn), inertance (I), and tissue damping (G) and elastance (H) in children with normal airways (*open and cross-batched bars with white background*) and with airway susceptibilities (AS, *open and cross-batched bars with gray background*) during propofol, and 13 min after sevoflurane and desflurane administration in children receiving either sevoflurane (*open bars*) or desflurane (*cross-batched bars*) first. Data are mean ± SEM (n = 10 for each column). # *P* < 0.05, normal *versus* bronchial hyperreactivity for a given inhalation agent. § *P* < 0.05, sevoflurane (Sevo) *versus* desflurane (Des) within a group. * *P* < 0.05 *versus* propofol within a group.

sevoflurane administration. In contrast, desflurane induced moderate and statistically significant increases in Rn (18.2 ± 2.8%), I (15.1 ± 2.1%), G (24.1 ± 3.5%), and H (7.8 ± 1.7%) in children with normal airways. However, in children with AS, greater increases were observed in Rn (53.9 ± 5%) and I (30.8 ± 3.9%), whereas the elevations in G (21.9 ± 3.3%) and H (9.8 ± 2.8%) were comparable to those observed in the children with normal airways.

Figure 4 demonstrates the changes in Rn after administration of the anesthetic volatile agents in the subgroups of children with AS. Children in both subgroups exhibited no statistically significant changes in Rn during sevoflurane inhalations, whereas desflurane caused significant increases in the Rn. In addition, table 2 depicts the values for Rn at the different assessment periods for children with doctor-diagnosed asthma with relation to the randomization to the anesthetic agent and to whether children received salbutamol therapy on day of surgery. The small number of patients does not allow any statistical analysis; however, children who received salbutamol on the day of surgery exhibited higher airway resistance values than those who did not.

Discussion

The results of the current study demonstrated that children with susceptible airways exhibited elevated air-

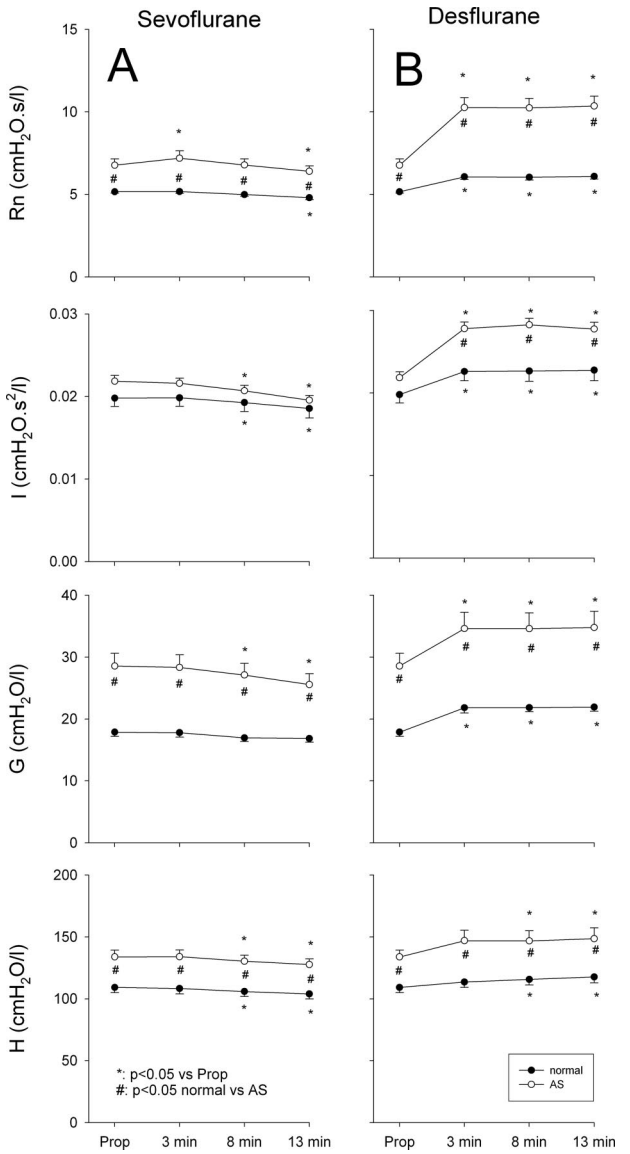

Fig. 2. Airway resistance (Rn), inertance (I), and tissue damping (G) and elastance (H) in children with normal airways (*open symbols*) and/or with airway susceptibility (AS, *closed symbols*). Data are pooled independently of the order of administration of the volatile agents and presented during propofol (Prop) and at 3, 8, and 13 min after administration of sevoflurane (*A*) and desflurane (*B*). Data are mean ± SEM (n = 20 in each group). * *P* < 0.05 *versus* propofol within a group. # *P* < 0.05, normal *versus* AS.

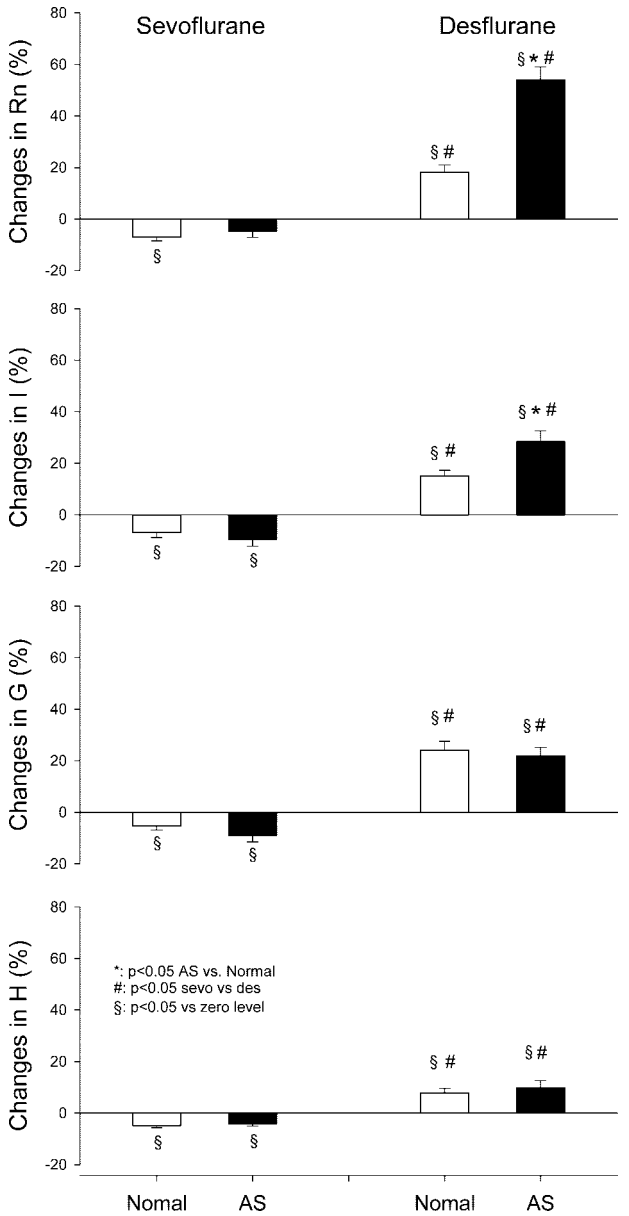

Fig. 3. Percentage changes in airway resistance (Rn), inertance (I), and tissue damping (G) and elastance (H) in children with normal airways (*open bars*, n = 20) and with airway susceptibility (AS, *filled bars*, n = 20) relative to the parameter value obtained during propofol anesthesia. Data are mean ± SEM. * *P* < 0.05, normal *versus* AS. # *P* < 0.05, sevoflurane (sevo) *versus* desflurane (des). § *P* < 0.05, *versus* zero level.

way and respiratory tissue mechanical parameters during propofol anesthesia compared with those obtained in similar-age children with normal airways. Changing the anesthetic management to sevoflurane led to mild improvements in the mechanical parameters of the respiratory system in all children with no impact from the presence of AS on the relative changes in respiratory mechanics. In contrast to the effects of sevoflurane, administering desflurane at any time during the anesthesia resulted in marked increases in all respiratory mechanical parameters, with substantially greater adverse changes in the airway mechanics in the children with AS. These marked adverse changes were independent of the underlying clinical status (asthma or upper respiratory tract infection) leading to AS.

Methodologic Considerations

We enrolled preschool children with no history of pulmonary disease and children with a recent upper respiratory tract infection and/or doctor-diagnosed asthma with a history of wheezing in the past 12 months. Because no reliable routine lung function tests are available in this age group, we were unable to perform

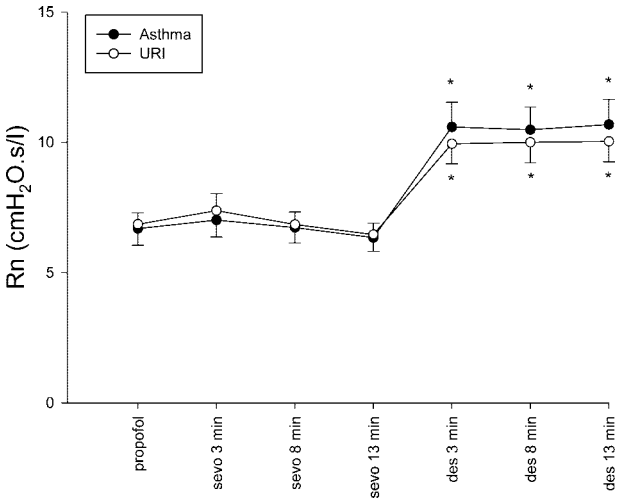

Fig. 4. Changes in the airway resistance (Rn) during sevoflurane (sevo 3 min–sevo 13 min) and desflurane (des 3 min–des 13 min) administration in children with susceptible airways due to asthma or recent upper respiratory tract infection (URI). Data are mean ± SEM (n = 10 in each group). * $P < 0.05$ *versus* propofol.

provocation tests to confirm the presence of BHR. Nevertheless, it has been well demonstrated that older children with these clinical features exhibit enhanced airway reactivity to exogenous constrictor stimuli.[6,29] Therefore, it can be expected that children enrolled to our AS group would exert greater responses to exogenous stimuli compared with healthy controls. This assumption was confirmed by the elevated baseline airway and tissue mechanical parameters obtained during propofol anesthesia. Another important feature that may lead to BHR is passive smoking. Unfortunately, in our study group, we only have two children in the control and three in the AS group with history of parental smoking. These small figures preclude any exact statistical analysis of this confounding factor and will be a subject of future investigations. Moreover, children in the AS group were quite heterogeneous in regard to their degree of airway reactivity; hence, some of the children received salbutamol on the day of surgery, whereas others did not (table 2). If salbutamol had affected the interaction between airway reactivity and inhalational anesthetics, one might have expected an equal or smaller resistance in those treated with salbutamol. Because children who received salbutamol demonstrated a 10–15% greater airway resistance than those who did not, it would be unlikely that salbutamol increased the resistance directly or interacted with the inhalational anesthetics. Therefore, it is unlikely that the inclusion of these children might have introduced a systematic error or bias.

The study design required establishing basal levels of respiratory mechanics for comparison with values obtained during the administration of volatile anesthetics. Ideally, these basal values should have been collected without administration of any anesthetic agents. However, the measurement of low-frequency Zrs data assumes apneic conditions that do not prevail without paralysis and accompanying anesthesia. Propofol was chosen as the baseline anesthetic condition because this agent has been demonstrated to protect from the vagally mediated bronchoconstriction that can occur after tracheal intubation.[30] In addition, this agent exerts identical effects in children with and without AS,[31] guaranteeing the validity of baseline measurements.

The mechanical parameters derived from the low-frequency Zrs data provide a noninvasive technique to estimate airway and tissue mechanical variables separately.[25,32] Because changes in the respiratory system are expected to affect both the airway and tissue compartments, this approach was considered as an appropriate and sensitive technique to characterize the changes in the lungs during propofol anesthesia and after the administration of volatile agents. Consistent with this, we were able to

Table 2. Airway Resistance at the Different Assessments for Children with Doctor-diagnosed Asthma

Child	Propofol	Sevo 3 min	Sevo 8 min	Sevo 13 min	Des 3 min	Des 8 min	Des 13 min	First Agent	Salbutamol
2	6.5	7.5	7.3	7.0	11.6	11.4	11.6	Des	No
3	4.5	4.2	4.2	4.0	9.6	9.5	9.6	Sevo	No
5	5.5	5.2	5.2	5.2	6.5	6.6	6.6	Sevo	No
6	10.6	10.5	9.7	8.5	14.5	15.2	15.0	Des	No
8	6.2	5.7	5.5	5.5	9.3	9.1	9.4	Sevo	No
10	5.6	6.8	6.4	5.9	8.5	8.8	8.8	Des	No
Mean	6.5	6.7	6.4	6.0	10.0	10.1	10.2		
SD	2.1	2.2	1.9	1.6	2.7	2.9	2.9		
1	10.3	9.9	9.8	9.5	16.0	14.0	16.0	Sevo	Yes
4	5.5	6.4	6.1	5.8	8.6	8.9	8.6	Des	Yes
7	6.5	8.4	7.4	6.8	12.6	12.7	12.7	Des	Yes
9	5.6	5.5	5.5	5.2	8.8	8.6	8.5	Sevo	Yes
Mean	7.0	7.6	7.2	6.8	11.5	11.1	11.5		
SD	2.3	2.0	1.9	1.9	3.5	2.7	3.6		

Randomization to anesthetic agent and salbutamol therapy on day of surgery is indicated.

Des = desflurane; sevo = sevoflurane.

obtain Zrs data in all children enrolled in the current study, and the model fitted well to Zrs spectra obtained from both groups of children under all anesthetic regimens (fitting errors ranging between 2.1% and 5.3%, with no difference between the conditions). Although this is the first study to report airway and constant-phase respiratory tissue parameters in healthy children, the current data exhibit good agreement with those obtained previously in children with congenital heart disease.[25,26] The parameters obtained from Zrs spectra in the current study combine mechanical properties of the lungs and chest wall. Previous findings in children indicate that the pulmonary system provides the majority of the Rn and I (more than 90%), whereas the chest wall contributes substantially to G and H (approximately 40%).[26] Therefore, it is likely that the airway parameters were estimated accurately from the Zrs data in our children, whereas the total respiratory G and H underestimated the changes in the lung tissue parameters. We assumed that this masking of the chest-wall parameters was similar between the two groups of children and remained constant after the administration of inhalation agents in the presence of muscle relaxation.[26]

Changes in Rn and I reflect geometrical alterations in the airways or can also be a consequence of the changes in the viscosity or density of the resident gas. Anesthetic inhalation agents administered at 1 MAC have slightly lower viscosity values (0.9% for sevoflurane and 1.7% for desflurane) but substantially greater density values (10.9% for sevoflurane and 22.4% for desflurane) than the 50% oxygen mixture alone.[33] Based on physical principles, Rn is influenced by the viscosity of the resident gas during laminar flow conditions, while density also affects this parameter only if the flow is turbulent. Altered density is directly reflected in the changes in I. Therefore, to distinguish the effects of the physical properties of the gas and the active changes in the airway geometry, we performed a model experiment where only the former was changed. Our simple lung model demonstrating similar mechanical parameters to those obtained in the children consisted of a 10-cm, 8-mm-ID tube filled with many small 8-gauge tubes (acting as an "airway" compartment) and a silicon bellow in series (acting as a "tissue" compartment), "ventilated" and measured during identical flow conditions to those followed in the our clinical protocol. The measurements revealed the relative constancy of Rn, G, and H when the resident anesthetic mixture was altered, whereas the parameter I reflected the differences in the density of the anesthetic gas (fig. 5). These results provide experimental evidence that the changes in Rn were almost exclusively related to geometric changes in the tracheobronchial tree (the minor increase in Rn with desflurane was probably due to the involvement of some flow nonlinearity), whereas those in I reflected primarily the difference in physical properties of the resident gas. Furthermore, the presence of the anesthetic agents did not modify the estimates of G and H in the model, suggesting that the changes observed in the patients were related to alterations in the viscoelastic properties of the respiratory system, and the elevations in G in excess of that in H could be related to enhanced ventilation heterogeneities.[34]

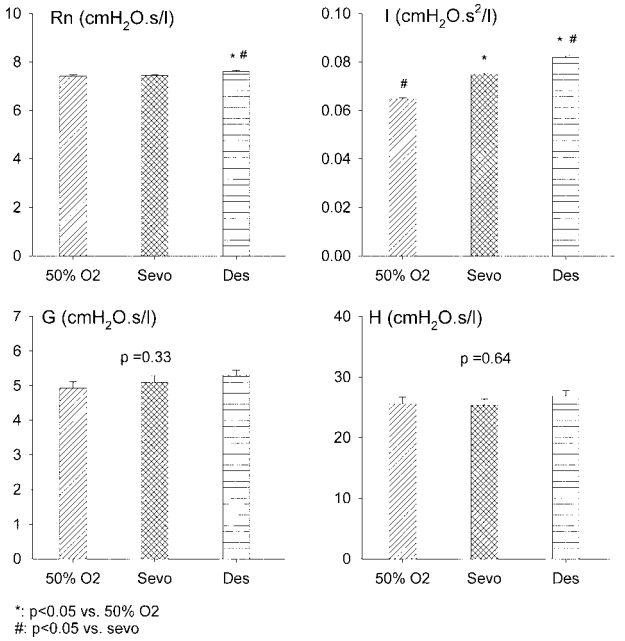

Fig. 5. Model parameters obtained from measurements of a mechanical lung model ventilated with 50% oxygen and during the same amount of volatile anesthetics given to children in the current study. Data are mean ± SEM. * *P* < 0.05 *versus* 50% oxygen. # *P* < 0.05 *versus* sevoflurane (Sevo). Des = desflurane; G = tissue damping; H = tissue elastance; I = airway inheritance; Rn = airway resistance.

Effects of Sevoflurane

Although the effects of sevoflurane on the respiratory system have been investigated intensively in animal experiments[11–14,35] and in studies in adult patients,[9,15] data relating to lung mechanics during sevoflurane anesthesia in children are scarce.[17,36] Furthermore, in these previous pediatric settings,[17,36] global respiratory mechanics were measured and the changes in the airway and tissue properties were not separated. In the current study, the mild bronchodilation effect of sevoflurane produced moderate decreases in Rn and I in both groups (fig. 3). These changes were associated with small but significant decreases in respiratory tissue parameters and could have been a consequence of the bronchodilation effect that facilitated lung recruitment by keeping the small bronchi patent. Nevertheless, these statistically significant differences obtained during sevoflurane anesthesia are likely to have a minor impact on clinical outcomes. The mild bronchodilatory effect of sevoflurane that we observed in children with and without AS is the first confirmation of similar results obtained in adults,[9,15] and in experimental settings where sevoflurane protects

from or reverses lung constriction in normal[11–14] and sensitized animals.[35]

Effects of Desflurane

Although desflurane is increasingly used in children because of its low solubility and fast action,[37,38] we are unaware of any previous study assessing the changes in respiratory mechanics in children after administration of this anesthetic agent. The most striking findings of the current study were the adverse changes in the airway and tissue mechanics observed during desflurane anesthesia, independent of the preexisting respiratory mechanical condition (*i.e.*, the order of administration of the agents and the underlying clinical symptoms). The adverse airway effects were significantly exaggerated in children with AS, whereas the presence of AS had no influence on the desflurane-induced increases in respiratory tissue parameters. This changing pattern can be explained by the potential of this agent to induce airway narrowing reflected by the increase in Rn and I, particularly in children with AS who are more sensitive to the irritative nature of desflurane.[9,39,40] The bronchoconstriction likely included the peripheral airways, because the proportionally greater increases in G than H suggest the development of ventilation heterogeneities in the lung periphery,[34] although intrinsic changes in lung tissue viscoelasticity might also have been involved in these changes. It is noteworthy that the airways of children with recent upper respiratory tract infection behaved the same way than those of children with asthma, indicating that both conditions lead to an AS of apparently similar nature and exhibit an enhanced response to desflurane.

Summary and Implications

The current study provides objective and systematic measurements of airway and respiratory tissue mechanics in children with normal lungs and with AS. The results show the beneficial profile of sevoflurane on the respiratory system mechanics independent of the clinical status of the child, whereas the deleterious effects of desflurane were apparent in all children, although with a markedly exaggerated airway narrowing in children with susceptible airways. We therefore conclude that the use of desflurane should be avoided in the anesthesia of children who exhibit a clinical history of recent upper airway infection or any other pulmonary disease that may be associated with AS.

The authors thank all the children and their families who participated in this study and Joan Etlinger, B.A. (Secretary, Department of Anesthesia, University of Basel, Basel, Switzerland), for editorial assistance.

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