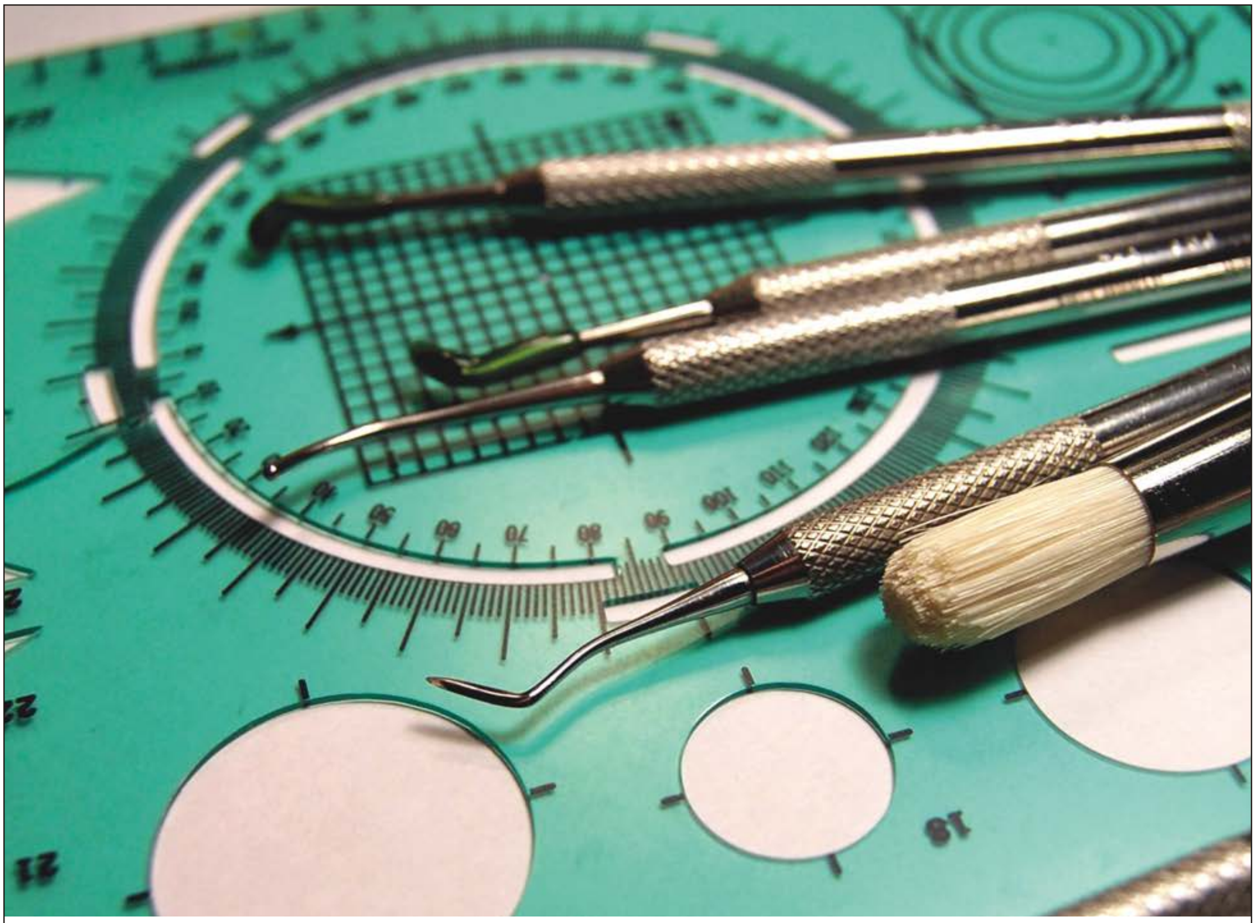

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Adenoidectomy-Induced Bradycardia in Anesthetized Children

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Abstract: The aim of this study was to evaluate the hemodynamic effects of adenoidectomy under general anesthesia from May 2004 to August 2008. In this retrospective study, 747 patients from 1 to 15 years of age were scheduled underwent general anesthesia with mixture of thiopentone with atracurium, fentanyl and glucose-free solutions, for adenoidectomy surgery compatible with the technique. The following factors were assessed: age, ASA physical status, gender, preoperative, during operation and post-operative pulse rate. A total of 747 adenoidectomy were performed during the study period. One hundred and twenty three cases (16.46%) had bradycardia during adenoidectomy. More population were under 3 years old (49.55%) and males (76.7%). Out of 123 cases that developed bradycardia, 80 cases without need to atropine treatment and only 43 cases that need intravenous Atropine for control of it. Adenoidectomy is the most common operations performed in children under general anesthesia. Adenoidectomy related incidents were the most common cause and were more likely to occur during the maintenance phase of anesthesia, due to the vagal stimulation. Bradycardia due to surgery stimulation happened very early and patients were able to recover from the administration of atropine.

Key words: Adenoidectomy, general anesthesia, bradycardia, pulse monitoring

INTRODUCTION

Adenoidectomy is one of the most commonly performed pediatric procedures in the world. The most common indications for the procedure include chronic serous otitis media (often combined with bilateral myringotomy and tubes insertion) and airway obstruction (due to adenoid hyperplasia). However, another important indication for adenoidectomy is in the management of medically refractory chronic pediatric rhinosinusitis. Pediatric rhinosinusitis continues to be a prominent public health issue as pediatric out patient visits for upper respiratory infection are second ouly to well baby visits amongst pediatric primary care providers. The care of children during anesthesia challenges all anesthesiologists, because a straightforward surgical procedure can suddeuly become a critical incident at any time. Cardiac arrest is the most critical incident during anesthesia and can lead to deterioration in the neurological status of the patient and subsequent death. In children, progressive bradycardia is the most common antecedent of cardiac arrest during anesthesia (Keenan and Boyan, 1985; Morray *et al*., 1993). The maintenance of systemic blood pressure in children is dependent on a trinity of factors: cardiac output, the production of stroke volume and heart rate. Because stroke volume is

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relatively fixed when the left ventricle is noncompliant and poorly developed, especially in neonates and infants, the cardiac output will therefore become very dependent on heart rate (Watterson *et al*., 2005; Armendi and Todres, 2003). Bradycardia can have a profound effect on organ perfusion and oxygenation, particularly in anesthetized children whose homeostatic mechanism may be impaired by anesthetic agents (Watterson *et al*., 2005). It had been estimated in earlier reports that the incidence of bradycardia in anesthetized children was 0.13-3.7%, according to the patients' status (Murat *et al*., 2004; Keenan *et al*., 1994; Borland *et al*., 2004). This retrospective study was conducted to evaluate the hemodynamic effect of adenoidectomy in 747 children less than 15 years old. However, the incidence, the causes and the outcomes of bradycardia during anesthesia in adenoidectomy candidate children at our country have not been studied. As a consequence, we decided to conduct this study aimed at determining the incidence, the causes and the outcomes of anesthetized children in relation to the occurrence of bradycardia.

MATERIALS AND METHODS

Patient's Evaluation

The study was approved by the Ethics Committee of the Ahwaz Jondishapour University of Medical Sciences and informed parent onset, 747 pediatric patients aged between birth and 15 years of age underwent general anesthesia with glucose-free solutions at Imam and Apadana Hospitals (Ahwaz, Iran) from May 2004 to August 2008. The children were starved for solids or milk for at least 6 h but were allowed clear fluids for up to 2 h before induction. All children were premedicated with oral midazolam (0.8 mg kg^{-1}), 20 min before arrival time in the operating room. General anesthesia was induced with thiopentone 4-5 mg kg^{-1} in children who preferred IV induction. The remainder was induced with oxygen, nitrous oxide and isoflurane. After induction of anesthesia, suxamethonium 1.5 mg kg^{-1} IV was given to facilitate tracheal intubation. Anesthesia was maintained with isoflurane 1.5-2.5% in 66% nitrous oxide in oxygen. Heart rate and blood pressure were adjusted to be within 20% of the baseline induction values by titrating isoflurane concentration and administering fentanyl 1-2 µg kg^{-1} IV. After recovery from suxamethonium all children were received atracurium 0.5 mg kg^{-1} until completion of surgery. Intravenous access was then obtained and 0.9% sodium chloride infusion at a rate of 30 mL h^{-1}, to be corrected afterwards. As practiced at the hospital, bradycardia in anesthetized children is defined by generally accepted heart rates less than the average value for their age, but not at a child's lowest limit because an anesthetized child's homeostatic mechanism may be required to overcome the impairment by anesthetic agents. A heart rate less than 100 beats min^{-1} in children aged under 3 years old, or a heart rate less than 60 beats min^{-1} in children aged 3-9 years old, and/or requiring the treatment of atropine administration by anesthesia providers in each situation were noted. Perioperative monitoring consisted of noninvasive blood pressure at 5 min intervals, heart rate and pulse oximetry (SpO2). ECG was continuously monitored at CM5. If the blood pressure decreased by 30% of baseline values then 7 mL kg^{-1} of a saline solution was given as a bolus as well as ephedrine, 0.7 mg kg^{-1} as needed. If the heart rate decreased by 15%, 0.01 mg kg^{-1} atropine was administered. Throughout the 4 years period at the hospital, anesthetic record forms, both paper-based and computer-based, had continued to improve the completion of patient details. For this study, we accessed information comprised of anesthetic records, medical records and the departmental database. This database contained information filled out at the time the events occurred in anesthesia and operative care and focused particularly on intra-operative complications by anesthesia providers. We recorded the data as: (1) patient factors: age, sex, weight, associated problems and the American Society of Anesthesiologists (ASA) physical status, (2) operative factors: case characteristics (elective/emergency or out-patient/inpatient), operative site (anatomic) and (3) anesthetic factors from the induction state to the post-anesthesia state, involving the anesthetic technique, airway maintenance, and anesthetic agents. For the analysis of influencing factors, each incident of bradycardia was examined for possible remarkable causes, the phase of anesthesia at the time of bradycardia and its outcome. After reviewing all data, we categorized each bradycardia incident as patient-related, operation-related, anesthesia-related or combined-related according to the primary cause of bradycardia noted at the time of occurrence. In cases where data could not be determined as cause and factor-related, we classified them as undetermined. The outcomes of patients with an occurrence of bradycardia in present study were directly related to the causes of bradycardia. They were classified into 5 groups:

- **No harm:** Complete recovery after removing surgery stimulations
- **Minor:** Small physiological changes without serious morbidity, such as transient hypotension, delayed emergence, etc. and complete recovery after prompt treatment
- **Major:** A serious situation which contributed to postoperative morbidity, such as ICU admission, operative postponement, neurological events, etc.
- Cardiac arrest, but without subsequent death
- Death on the operating table or postoperatively

Statistical Analysis

Analysis were performed using SPSS 10. Descriptive statistics were used to describe the frequency in patients' data, shown as number and percent (%). The degree of risk factors for bradycardia are shown as Odds Ratio (OR) and were compared by using a Chi-square test. Values of $p<0.05$ were considered statistically significant.

RESULTS

Of 747 children, 123 cases were reported with bradycardia, the incidents were composed of 78 males and 45 females with a weight range of 1 to 48 kg and a height range of 30.0 to 133.0 cm (Table 1, 7). Bradycardia occurred during all phases of anesthesia, with 2.8% occurring in the induction phase, 94.1% in the maintenance phase, 1.7% in the emergence phase and 1.4% in the post-anesthesia phase. It is likely that the most common cause of bradycardia was as a result of surgery stimulation, 65.7% (n = 81). The etiology of the other cases were cardiovascular, 2.1% (n = 3); respiratory, 4.2% (n = 6); central nervous system, 9.5% (n = 12); multiple causes, 6.3% (n = 9) and those with an unknown etiology 9.5% (n = 12), in that order (Table 4). Of all causes of bradycardia, 13% (n = 16) were anesthesia-related, 55.28% (n = 68) adenoidectomy-related, 26% (n = 32) patient-related and 5.69% % (n = 7) combined-related (Table 5). For ASA physical status 1 and 2, the most common causes were operation-related. Most predominant type of bradycardia cases was 81 cases without need to atropine treatment and 12 cases that need intravenous Atropine for control of it (Table 6). There was no cardiac arrest or death in study patients that mostly were in ASA physical status 1 and 2. The frequency of the presence or absence of bradycardia as categorized by age and ASA physical status, service is shown in Table 2. The frequency of bradycardia in children under 3 years of age was significantly higher than for children over 3 years of age (Odds ratio = 1.96, 95% confidence

Table 1: Demographic data of 747 children less than 15 years old

Variables	No. of patients
Age (years)	
0-3	223
3-6	202
6-9	208
9-12	82
12-15	32
Gender	
Male	554
Female	193

Table 2: The frequency of presence and absence of bradycardia categorized by patient factors for 331 incidents from 747 adenoidectomied children

Variables	Bradycardia (n) (%)	No bradycardia (n) (%)
Age (years)		
0-3 *	164 (21.9)	59 (7.8)
3-6	103(13.7)	99 (13.2)
6-9	45(6.2)	163 (21.8)
9-12	19(2.5)	63 (8.4)
12-15	0	32 (4.2)
Total	331(44.3)	416 (55.7)
ASA		
1, 2*	307 (41.1)	410 (54.9)
5-Mar	24(3.2)	6 (0.8)

* p<0.01

Table 3: Comparison of the frequency of bradycardia for 331 incidents

Variables	Odd ratio	95% confidence limit	p-value
Age <3 years	1.96	1.61-2.74	≤0.01
ASA 1 and 2	2.34	1.97-3.21	≤0.01

Table 4: Classification the causes of bradycardia among study group

Causes of bradycardia	Number	Percent
Surgery	81	65.7
Central nervous	12	9.5
Respiratory	6	4.2
Cardiovascular	3	2.1
Multiple	9	6.3
Unknown	12	9.5
Total	123	100.0

Table 5: Bradycardia classification based on causes in different ASA physical status

Cause of bradycardia	ASA classes	No.
Patient related	I	10
	II	24
	III	8
	IV	2
	V	0
Adenoidectomy related	I	15
	II	33
	III	6
	IV	4
	V	0
Anesthesia related	I	5
	II	8
	III	1
	IV	0
	V	0
Combined	I	2
	II	3
	III	1
	IV	1
	V	0

interval = 1.61-2.74, $p \leq 0.001$). The frequency of bradycardia in ASA physical status 1 and 2 children was not significantly higher than for children in ASA physical status 3 to 5 (Odds ratio = 2.41, 95% confidence interval = 1.97-4.12, p = 0.473). There was no significant difference in the frequency of bradycardia between emergency and elective cases or between in- patient and outpatient cases (Table 3).

Table 6: ASA physical status classification of bradycardia

Causes of bradycardia	ASA classes	Number
Group 1	I	20
	II	47
	III	10
	IV	3
	V	0
Group 2	I	15
	II	17
	III	7
	IV	0
	V	0
Group 3	I	1
	II	4
	III	0
	IV	0
	V	0
Group 4	I	0
	II	0
	III	0
	IV	0
	V	0
Group 5	I	0
	II	0
	III	0
	IV	0
	V	0

Groups: 1: No harm: Complete recovery after removing surgery stimulations; 2: Minor: Small physiological changes without serious morbidity, such as transient hypotension, delayed emergence, etc. and complete recovery after prompt treatment; 3: Major: A serious situation which contributed to post-operative morbidity, such as ICU admission, operative postponement, neurological events, etc.; 4: Cardiac arrest, but without subsequent death and 5: Death on the operating table or postoperatively

Table 7: Bradycardia recorded at different age group in males and females

	Gender (%)	
Variables	Female	Male
Age group (years)		
0-3	9.67	39.88
3-6	8.46	22.66
6-9	4.23	90.37
9-12	0.91	40.83
12-15	0.00	0.00

DISCUSSION

Bradycardia is the most common antecedent event for cardiac arrest in children, at 54%, during anesthesia (Morray *et al*., 2000; Bhananker *et al*., 2007). Incidences of bradycardia in anesthetized children vary for age group and are estimated to be from 0.13 to 3.7% (Murat *et al*., 2004; Keenan *et al*., 1994; Borland *et al*., 2004). Some patients have a greater risk of bradycardia during anesthesia. These include patients with down syndrome, due to the considerable number having congenital heart disease, 38.6-50.0% (Borland *et al*., 2004; Roodman *et al*., 2003; Jaruratanasirikul *et al*., 2004). They may also exhibit airway difficulties and pulmonary hypertension which causes hypoxia during anesthesia administration (Jaruratanasirikul *et al*., 2004). This study mainly describes the characteristics of anesthetized children underwent adenoidectomy with bradycardia during a 4 years period (2004-2008) at Imam and Apadana Hospitals. During this period, 747 children were anesthetized and 331 cases of bradycardia from all causes were detected. Present study showed that adenoidectomy-related, vagal stimulation (73.7%) during an operative procedure was the most common cause of bradycardia but in case of severity only 87 cases (26.28%) need atropine treatment. Of these, equipment-related bradycardia cases were the most frequent at 87.9%.

Present study was different with a earlier study by Watterson *et al*. (2005) and Keenan *et al*. (1994) which reported that the major causes of bradycardia were medications, airway problems and autonomic reflexes-related events. However, Green *et al*. (2000) reported that the onset of a nodal rhythm, associated with bradycardia began significantly earlier in children who had received an 8% induction concentration of sevoflurane compared with incremental amounts of 2% sevoflurane, every four to six breaths.

Desalu *et al*. (2004, 2005) and Constant *et al*. (1999) reported that children induced with incremental amounts of halothane of up to 3% with 33% oxygen and nitrous oxide had a significant drop in blood pressure for all patients, although heart rate values were significantly less during post-induction in children older than 1 year. Of these, no patient experienced bradycardia. Annila *et al*. (1998) reported that the incidence of bradycardia was 24% during the halothane maintenance of anesthesia when no patient had received atropine pre-treatment. However, these bradycardia events were short-lived and patients were able to recover spontaneously whereas the administration of atropine as a pretreatment to prevent bradycardia caused persistent tachycardia. Therefore, the routine prevention of bradycardia by atropine is not necessary in children undergoing halothane anesthesia. A earlier report showed that succinylcholine could itself induce unexpected bradycardia and tachyarrhythmia, but rarely asystole (McAuliffe *et al*., 1995; Shorten *et al*., 1995) or secondary to succinylcholine-induced rhabdomyolysis in patients with undiagnosed muscle disease (Sullivan *et al*., 1994). Some have suggested that anesthesia for healthy children, when used as a muscle relaxant, should not be achieved by succinylcholine (Schulte-Sasse *et al*., 1993). Atropines, at 0.02 mg kg^{-1} or glycopyrrolate, at 0.01 mg kg^{-1} are equally effective in attenuating succinylcholine-induced bradycardia in children (Lerman and Chinyanga, 1983). Currently, atropine, at 0.1 mg is offered as adequate protection against this type of bradycardia in all age groups for infants and children (Davis *et al*., 2006). In this study, vagal stimulation accounted for 73.7% of the various types of stimuli such as oculocardiac reflex, peritoneal traction, laryngoscopy and vagus nerve traction. The presence of increased intracranial pressure may enhance the vagal tone, which is precipitated by operative procedures such as burr holes or ventriculostomy, which has an incidence of 10.2-41.0% of bradyarrhythmia (Baykan *et al*., 2005; El-Dawlatly *et al*., 2000). It is also important to note that we should be particularly careful when administering anesthesia to children with increased intracranial pressure. The major finding in this study indicates that the frequency of bradycardia in patients under 3 years of age was significantly higher than for patients over 3 year of age (Odds ratio = 1.96, 95% confidence interval = 1.61-2.74, $p \leq 0.001$). Moreover, the frequency of bradycardia in ASA physical status 1 and 2 children was not significantly higher than for children with an ASA physical status of 3 to 5 (Odds ratio = 2.41, 95% confidence interval = 1.97- 4.12, $p = 0.473$). This study concurs with the study by Keenan *et al*. (1994) in that the frequency of bradycardia was higher in the 1st year of age, compared with children aged three and 4 years of age. Sick infants who frequently undergo emergency or prolonged surgical procedures together with an immature sympathetic nervous system and a baroreceptor reflex appear particularly prone to episodes of bradycardia, cardiac arrest, and death. Additioually, a sick infant's cardio-vascular system maintains lower catecholamine stores, displays a blunted response to exogenous catecholamine and is more sensitive to calcium chaunel blocking properties of volatiles anesthetic which induces bradycardia (Armendi and Todres, 2003). Although basal heart rate in children is higher than in adults, anesthetic overdose, hypoxia or the activation of the parasympatic nervous system can cause bradycardia. A bolus injection of atropine is the 1st pharmacologic form of intervention and may attenuate excessive vagal tone. Moreover, bradycardia should be immediately treated with oxygen and, if necessary with ventilation. If severe bradycardia occurs suddeuly during anesthesia, it is essential that anesthesiologists clarify the underlying cause, as in the administration of oxygen, ensuring a clear and patent airway and administration of atropine. Precordial stethoscopy is still a useful monitor for the early detection of heart rate changes and may be an early warning sign of a reduction in cardiac output (Manecke *et al*., 1999; Anandh *et al*., 2002). In conclusion, adenoidectomy-related incidents were the most common cause and were more likely to occur during the maintenance phase of anesthesia, due to the vagal stimulation. Bradycardia due to surgery stimulation happened very early and patients were able to recover from the administration of atropine. Anesthetized children under 3 years of age had a significantly higher risk than other children.

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REFERENCES

Anandh, B., K.R.R. Madhusudan, A. Mohanty, G.S.R. Umamaheswara and B.A. Chandramouli, 2002. Intraoperative bradycardia and postoperative hyperkalemia in patients undergoing endoscopic third ventriculostomy. Minim. Invasive. Neurosurg, 45: 154-157.

Annila, P., M. Rorarius, P. Reinikainen, M. Oikkonen and G. Baer, 1998. Effect of pre-treatment with intravenous atropine or glycopyrrolate on cardiac arrhythmias during halothane anaesthesia for adenoidectomy in children. Br. J. Anaesth., 80: 756-760.

Armendi, A.J. and I.D. Todres, 2003. Postanesthesia Care Unit. In: The practice of anesthesia for infants and children, Cote, C.J., I.D. Todres, N.G. Goudsouzian and J.F. Ryan, (Eds.), W.B. Saunders, Philadelphia, ISBN: 978-0-7216-9257-9, pp: 698-714.

Baykan, N., O. Isbir, A. Gercek, A. Dagcnar and M.M. Ozek, 2005. Ten years of experience with pediatric neuroendoscopic third ventriculostomy: Features and perioperative complications of 210 cases. J. Neurosurg Anesthesiol., 17: 33-37.

Bhananker, S.M., C. Ramamoorthy, J.M. Geiduschek, K.L. Posner, K.B. Domino, C.M. Haberkern, J.S. Campos and J.P. Morray, 2007. Anesthesia-related cardiac arrest in children: Update from the pediatric perioperative cardiac arrest registry. Anesth. Analg., 105: 344-350.

Borland, L.M., J. Colligan and B.W. Brandom, 2004. Frequency of anesthesia-related complications in children with down syndrome under general anesthesia for noncardiac procedures. Paediatr. Anaesth., 14: 733-738.

Constant, I., M.C. Dubois, V. Piat, M.L. Moutard, M. McCue and I. Murat, 1999. Changes in electroencephalogram and autonomic cardiovascular activity during induction of anesthesia with sevoflurane compared with halothane in children. Anesthesiology, 91: 1604-1615.

Davis, P.J., J. Lerman, S.P. Tofovic and D.R. Cook, 2006. Pharmacology of Pediatric Anesthesia. In: Anesthesia for Infants and Children, Motoyama, E.K. and P.J. Davis (Eds.). Mosby, Philadelphia, pp: 177-238.

Desalu, I., O.T. Kushimo and C.O. Bode, 2005. A comparative study of the haemodynamic effects of atropine and glycopyrrolate at induction of anaesthesia in children. West Afr. J. Med., 24: 115-119.

Desalu, I., O.T. Kushimo and M.A. Odelola, 2004. Cardiovascular changes during halothane induction in children [Abstract]. Niger Postgrad Med. J., 11: 173-178.

El-Dawlatly, A.A., W.R. Murshid, A. Elshimy, M.A. Magboul, A. Samarkandi and M.S. Takrouri, 2000. The incidence of bradycardia during endoscopic third ventriculostomy. Anesth. Analg., 91: 1142-1144.

Green, D.H., P. Townsend, O. Bagshaw and M.A. Stokes, 2000. Nodal rhythm and bradycardia during inhalation induction with sevoflurane in infants: A comparison of incremental and high-concentration techniques. Br. J. Anaesth., 85: 368-370.

Jaruratanasirikul, S., S. Soponthammarak, P. Chanvitan, P. Limprasert, H. Sriplung, W. Leelasamran and S. Winothai, 2004. Clinical ab-normalities, intervention program, and school attendance of down syndrome children in Southern Thailand. J. Med. Assoc. Thai., 87: 1199-1204.

Keenan, R.L. and C.P. Boyan, 1985. Cardiac arrest due to anesthesia. A study of incidence and causes. JAMA., 253: 2373-2377.

Keenan, R.L., J.H. Shapiro, F.R. Kane and P.M. Simpson, 1994. Bradycardia during anesthesia in infants. An epidemiologic study. Anesthesiology, 80: 976-982.

Lerman, J. and H.M. Chinyanga, 1983. The heart rate response to succinylcholine in children: A comparison of atropine and glycopyrrolate. Can. Anaesth. Soc. J., 30: 377-381.

Manecke, G.R., M.A. Nemirov, A.A. Bicker, R.N. Adsumelli and P.J. Poppers, 1999. The effect of halothane on the amplitude and frequency characteristics of heart sounds in children. Anesth. Analg., 88: 263-267.

McAuliffe, G., B. Bissonnette and C. Boutin, 1995. Should the routine use of atropine before succinylcholine in children be reconsidered?. Can. J. Anaesth., 42: 724-729.

Morray, J.P., J.M. Geiduschek, R.A. Caplan, K.L. Posner, W.M. Gild and F.W. Cheney, 1993. A comparison of pediatric and adult anesthesia closed malpractice claims. Anesthesiology, 78: 461-467.

Morray, J.P., J.M. Geiduschek, C. Ramamoorthy, C.M. Haberkern and A. Hackel *et al*., 2000. Anesthesia-related cardiac arrest in children: Initial findings of the Pediatric Perioperative Cardiac Arrest (POCA) registry. Anesthesiology, 93: 6-14.

Murat, I., I. Constant and H. Maud'huy, 2004. Perioperative anaesthetic morbidity in children: A database of 24,165 anaesthetics over a 30-month period. Paediatr. Anaesth., 14: 158-166.

Roodman, S., M. Bothwell and J.D. Tobias, 2003. Bradycardia with sevoflurane induction in patients with trisomy 21. Paediatr. Anaesth., 13: 538-540.

Schulte-Sasse, U., H.J. Eberlein, I. Schmucker, D. Underwood and R. Wolbert, 1993. Should the use of succinylcholine in pediatric anesthesia be re-evaluated?. Anaesth. Reanim., 18: 13-19.

Shorten, G.D., B. Bissonnette, E. Hartley, W. Nelson and A.S. Carr, 1995. It is not necessary to administer more than 10 micrograms kg-1 of atropine to older children before succinylcholine. Can. J. Anaesth., 42: 8-11.

Sullivan, M., W.K. Thompson and G.D. Hill, 1994. Succinylcholine-induced cardiac arrest in children with undiagnosed myopathy. Can. J. Anaesth., 41: 497-501.

Watterson, L.M., R.W. Morris, R.N. Westhorpe and J.A. Williamson, 2005. Crisis management during anaesthesia: Bradycardia. Qual Saf. Health Care, 14: 9-9.