Pediatric Anesthesia

Pediatric Anesthesia ISSN 1155-5645

ORIGINAL ARTICLE

Perioperative complications in children with Apert syndrome: a review of 509 anesthetics

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Keywords
Apert syndrome; perioperative complications; mid-face hypoplasia; obstructive sleep apnoea; airway management

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Section Editor: Brian Anderson

Accepted 21 October 2010

doi:10.1111/j.1460-9592.2010.03457.x

Summary

Objectives: To perform a retrospective, anesthesia case note review in children with Apert Syndrome.
Aim: To identify perioperative complications in this group of patients.
Background: Apert syndrome is a rare autosomal dominant disorder characterized by craniosynostosis, craniofacial anomalies, and severe symmetrical syndactyly (cutaneous and bony fusion) of the hands and feet. Children with this syndrome require general anesthetics for a number of different operations and procedures. Our institution has records of 71 children with Apert syndrome. Analysis of their general anesthetic records was undertaken, and the incidence of perioperative complications was investigated.
Methods: A retrospective case note review was performed on 61 children with Apert syndrome over a 14-year period. There were a total of 509 general anesthetics administered to these children during this period of time.
Results: There were a total of 31 perioperative respiratory complications occurring in 21 patients (6.1% of the total cases). Twenty-three of these complications were supraglottic airway obstruction (4.5% of total cases).
Conclusions: We found there to be a low incidence of major perioperative major complications in this group of patients. Nevertheless, a significant proportion of these children have obstructive sleep apnoea and may develop supraglottic airway obstruction on induction and emergence from anesthesia due to the associated mid-face anatomical abnormalities.

Introduction

Apert syndrome is a rare disorder that generally occurs sporadically, although an autosomal dominant inheritance has been described (1). It is evident at birth, and accounts for 4.5% of all cases of craniosynostosis (premature fusion of one or more cranial sutures). Further craniofacial abnormalities include hypertelorism, mid-face hypoplasia, and choanal stenosis. Neurological and intracranial anomalies can include ventriculomegaly, hydrocephalus (2), and developmental delay (3). The other dominant clinical feature is symmetrical syndactyly of the fingers (4) and feet (cutaneous and bony fusion) generally tending to affect the upper limb more severely than the lower limb (5). There have also been reports of associated congenital cardiac and renal defects. There is fusion of the cervical spine in 68% of cases of Apert syndrome, mainly at C5–C6, distinguishing it from Crouzons syndrome where the fusion is usually at the C2–C3 level (6).

These features have clinical relevance to anesthetists as some degree of upper airway obstruction due to reduced nasopharyngeal volume and choanal patency is certain. Obstructive sleep apnoea is present in almost 50% (7) and cor pulmonale may result (8). There have also been descriptions of complete or partial cartilage sleeve abnormalities of the trachea, which have been postulated to cause lower airway compromise (9).

Children with this syndrome require general anesthetics for a number of different operations and procedures. It has been suggested that they have a much higher incidence of perioperative respiratory complica-

tions, particularly bronchospasm, than other children (10). There are very little published data looking specifically at perioperative outcomes in children with Apert syndrome. Reviews and reports tend to group them together with other craniofacial syndromes (11–13), so specific complications may be masked. Our institution has records of 71 children with Apert syndrome diagnosed clinically and genetically. Analysis of their general anesthetic records was undertaken and the incidence of perioperative complications was investigated.

Methods

Following ethical and audit committee advice, a retrospective case note review was performed on 71 children with Apert syndrome at Great Ormond Street Hospital. Eight case notes were untraceable during the period of time due to filing and tracking errors and therefore omitted from the series and a further two sets of case notes had no records of anesthesia. The anesthetic charts from the case notes of the remaining 61 children were analyzed for the 14-year period from 1995 until 2009.

Details of patient demographics and the procedures undertaken were collated. The patient's preoperative respiratory status was recorded, specifically looking for a sleep study diagnosis of obstructive sleep apnoea, a history of asthma or wheeze, tracheostomies, and previous respiratory admissions. Intra-operative airway management and complications were documented, and the postoperative period was evaluated.

Results

There was a total of 509 general anesthetics administered to 61 children (38 boys and 23 girls) during this 14-year period of time. Their ages ranged from 1 day to 15 years old, and they were classified as ASA II ($n = 77$) and ASA III ($n = 431$), with operation duration ranging from 10 min to over 4 h.

The most frequent reason for a general anesthetic was an orthopedic procedure (Table 1). Within the 224 operations undertaken, 115 of these were for a change of dressing. There were 46 major craniofacial operations, a majority of which were posterior vault expansions, frontal remodeling, and biparietal distractions (Table 2). The remaining minor craniofacial procedures included adjustments and removals of 'RED (Rigid Extraction Device) frames'.

Thirty-six children had a sleep study diagnosis of obstructive sleep apnoea preoperatively. Although we were unable to clarify the exact age of the children when they were diagnosed, their ages when presenting for surgery ranged from 6 weeks to 14 years. Two of these children, aged 11 and 12 years, were receiving home CPAP. Eight out of the nine adenotonsillectomy patients in this series were having the procedure in an attempt to ameliorate obstructive sleep apnoea (OSA). Only five of the patients had a history of asthma or being 'wheezy' in the past. Three of these children were taking regular inhalers for the condition. Six children had a tracheostomy at some point during their lives. The indication for four of these children was temporary insertion because of craniofacial surgery. One child had a tracheostomy at the age of 2 weeks to assist prolonged ventilatory requirements. One child had a definitive tracheostomy for severe obstructive sleep apnoea. Fifteen children had known choanal atresia, and one child had congenital subglottic stenosis. Eight of the children had been admitted to hospital with respiratory symptoms since birth, and on 16 occasions the patients had experienced a recent upper respiratory tract infection prior to their anesthetic (Table 3).

Atropine was prescribed before 216 anesthetics, and sedation was given before 44 procedures. In a majority of times, no premedication was given ($n = 293$). A majority of the anesthetics were initiated with a gas induction (251 vs 58 intravenous). Maintenance of anesthesia was with volatile agents in all but one of the anesthetics where total intravenous anesthesia was used. The patients received positive pressure ventila-

Table 1 Type of surgery

Type	Number of anesthetics
Orthopedics	224
ENT	79
Neurosurgery	62
Radiology	51
Craniofacial	46
Dental	18
Plastics/cleft surgery	10
General	10
Eyes	7
Urology	1
Cardiac	1

Table 2 Major craniofacial reconstructions

Procedure	Number of cases
Bipartition distraction	7
Monoblock distraction	5
Frontal remodeling	8
Cranial vault expansion	5
Posterior vault expansion	16

Table 3 Patient demographics

Operation duration		Ages		Weights (kg)		Preoperative respiratory status	
Duration (min)	No. of cases	Age	No. of patients	Weight (kg)	No. of patients	History	No. of patients
0–30	261	Neonates	4	<3	3	Obstructive sleep apnoea	36
31–60	65	4 weeks–6 months	69	3.1–6	51	CPAP	2
61–120	119	7–12 months	107	6.1–10	141	Asthma/wheeze	5
121–240	49	13 month–5 years	235	10.1–15	140	Regular inhalers	3
>241	15	6–11 years	52	15.1–20	87	Tracheostomy	6
		>12 years	40	20.1–40	52	Choanal atresia	15
				>41	83	Subglottic stenosis	1

tion for 225 of the anesthetics, and in the remaining 284 cases the child breathed spontaneously throughout the procedure.

The airway was managed in a variety of ways – face mask (n = 68, SV = 66, PPV = 2), laryngeal mask (n = 206, SV = 206), tracheal tube (n = 199, SV = 2, PPV = 197), and tracheostomy (n = 36, SV = 10, PPV = 26). The children were easy to intubate in a majority of cases with a Cormack and Lehane grade I (n = 181), grade II (n = 15), and grade III (n = 3). There were no children with a grade IV view. There were two cases where the laryngeal mask did not provide a good seal; one was managed with tracheal intubation and the other with a face mask.

Nasal prongs were *in situ* prior to 19 anesthetics in four children. Another six children had a nasal prong placed at the end of their operations.

In 98 of the 199 occasions, an age-appropriate tracheal tube size was used according to the formula: tracheal tube size (internal diameter in millimetres) = (age/4) + 4. In 68 instances, a larger tube size was required, and a smaller tracheal tube was placed in 28 cases. There were five anesthetics where the tube size was not documented (Table 4).

Peripheral access was documented in 457 of the anesthetics. On 52 occasions, there was no intravenous access. There were 45 arterial lines and 30 central venous catheters placed.

Table 4 Age-appropriate tracheal tube sizes (based on the formula: Tracheal tube internal diameter [mm] = age/4 + 4)

Tube size	Numbers	Percentage (%)
Age appropriate	98/199	49.2
Larger size	68/199	34.2
Smaller size	28/199	14.1
Unclear	5/199	2.5

Majority of orthopedic operations were upper limb procedures, and brachial plexus blocks (n = 80) were commonly performed. Limited abduction of the upper arm and 'winging' of the scapula in Apert syndrome make axillary brachial plexus block difficult to perform, and ultrasound guidance is helpful. The remaining regional blocks were caudal epidurals (n = 3) and an ankle block (n = 1).

There were a total of 31 perioperative respiratory complications occurring in 21 patients (6.1% of the total cases). Twenty-three of these complications were supraglottic airway obstruction (4.5% of total cases), which were easily resolved with simple airway manoeuvres, adjuncts or positive end expiratory pressure (Table 5). There was only one documented incidence of wheeze, which followed fentanyl and erythromycin administration and was clinically felt to be allergy related although no treatment was required. The child was 3 years old, having syndactyly release surgery and was breathing spontaneously through a laryngeal mask. The child had a recent upper respiratory tract infection (URTI) but subsequent anesthetic charts documented this event as an antibiotic allergy. Other problems were desaturation due to secretions down the tracheal tube, resolved with suctioning (x1); Laryngospasm requiring re-intubation (x1); Self-resolving stridor in recovery (x1); Postoperative upper airway clot after micro-laryngo-bronchoscopy (x1); Coughing on induction (x1); Obstruction of nasal prong on postoperative ward leading to respiratory arrest and PICU admission (x1); Desaturation and drowsiness in recovery after monoblock distraction (x1), which was successfully treated with naloxone and furosemide.

Five children had a past medical history of asthma/wheeze and three of them were taking regular inhalers for the condition; the patient who experienced wheeze under anesthesia was not one of this cohort. Thirty-six patients had a formal sleep study diagnosis of obstructive sleep apnoea, but only nine of these had documen-

Table 5 Details of patients who experienced supraglottic airway obstruction

Patient	Age	Known preoperative Upper Airway obstruction?	Surgery	Duration of surgery	Timing of obstruction	Manipulation of airway to overcome obstruction	Definitive airway for proceedure
1	3 years	Yes – OSA	Tonsillectomy and Adenoidectomy	60 min	Induction	Oropharyngeal airway	Tracheal tube
2	19 months	No	Fronto-orbital remodeling	6 h	Induction	Oropharyngeal airway	Tracheal tube
3a	8 months	Yes – OSA	Change of dressing	20 min	Induction	Oropharyngeal airway and PEEP	Face mask and oropharyngeal airway
3b	9 months	Yes – OSA	Change of dressing	20 min	Induction	Oropharyngeal airway	Face mask and oropharyngeal airway
3c	9 months	Yes – OSA	Tonsillectomy and Adenoidectomy	30 min	Induction	Oropharyngeal airway	Tracheal tube
4a	12 years	Yes – OSA. Nocturnal CPAP	Dental extractions	2 h 45 min	Induction	Jaw support and suction	Tracheal tube
4b	9 years	Yes – OSA	Tonsillectomy and Adenoidectomy, EUA ears	1 h 15 min	Induction	Jaw support	Tracheal tube
5	14 years	No	Correction of fixed flexion deformity of hand	40 min	Induction	PEEP	Tracheal tube
6	4 months	Yes – OSA/choanal atresia	Adenoidectomy, EUA postnasal space	60 min	Induction	Jaw support	Tracheal tube
7	5 months	Yes – OSA/choanal atresia	Frontal remodeling	4 h	Induction	LMA	Tracheal tube
8	5 years	Yes – OSA	Adenoidectomy	40 min	Induction	Jaw thrust	Tracheal tube
9	14 years	Yes – OSA	Syndactyly repair	1 h	Emergence	Oropharyngeal airway until awake	Tracheal tube
10a	9 months	Yes – OSA/choanal atresia	Nasal prong and dilation	20 min	Induction	Oropharyngeal airway and nasal prong	LMA
10b	2 years 10 months	Yes – OSA	CT Head	10 min	Induction	Oropharyngeal airway	LMA
11a	4 months	No	Cleft palate repair	1 h 30 min	Induction	Oropharyngeal airway	Tracheal tube
11b	9 months	No	Syndactyly repair	3 h 30 min	Induction	Oropharyngeal airway	Tracheal tube
12	12 months	No (subsequently diagnosed OSA)	Grommets	10 min	Induction	Oropharyngeal airway and PEEP	LMA
13	6 weeks	Yes – OSA	MLB and nasal prong	60 min	Induction	Nasal prong	Nasal prong
14	14 years	Yes – OSA	Cranial cyst enucleation	1 h 30 min	Emergence	Jaw thrust	Tracheal tube
15	4 years	No	Division of fingertips	60 min	Induction	Jaw thrust and PEEP	Tracheal tube
16a	7 months	No	Cranial remodeling	2 h	Emergence	Oropharyngeal airway	Tracheal tube
16b	4 years	No	Change of dressing	10 min	Induction	PEEP	Face mask
16c	9 years	No	Dental extractions	30 min	Emergence	Chin lift	Tracheal tube

PEEP, positive end expiratory pressure.

ted perioperative supraglottic airway obstruction. Only three children with a recent URTI had documented perioperative respiratory complications; one (described previously) associated with wheeze and allergy; one with tracheal tube secretions and the other with supraglottic airway obstruction.

There was one patient with a major bleed following a bipartition distraction who required unexpected admission to the PICU for ongoing management. Two children vomited, one on induction and the other on emergence, but neither resulted in aspiration.

Majority of patients returned to the ward/HDU environment after their operations ($n = 494$) with only 15 admissions to the PICU/NICU postoperatively.

Discussion

Although a retrospective case note review may well under-report complications, we are confident that major problems requiring treatment will have been captured. Overall, we found there to be a low incidence of major perioperative respiratory complications in this group of patients and in contrast to a previous publication (10), we found the incidence of bronchospasm to be extremely low at 0.2% and there were no cancellations of surgery due to respiratory complications.

The lower airway abnormalities described in the literature did not cause excessive problems in our cohort, tracheal tube size was either age appropriate or greater in 83.4% of the group and only one child had a documented congenital subglottic stenosis (9). In one child, there was desaturation related to partial obstruction of the tracheal tube by secretions and although this was easily resolved, we note that this complication has been reported previously (14). Tracheobronchial secretions may also cause lower airway obstruction and mimic bronchospasm, which may account for some of the cases previously described.

Our results showed that our group of patients were far more likely to experience supraglottic rather than infraglottic obstruction. It may be that this was underreported in our data, as minor degrees of supraglottic obstruction may not have caused the anesthetist or patient substantial problems and may have seemed unworthy of reporting. Simple airway manoeuvres and adjuncts usually rectified any upper airway obstruction documented. Majority of upper airway obstructions occurred on induction of anesthesia. There were only four incidences of postoperative obstructions. A common supposition would be to assume the incidence of postoperative problems occurs more frequently with longer intubations and prolonged surgery. Our results do not support this statement. Majority of the supraglottic obstructions occurred when the child was scheduled to have 'shared airway' surgery such as Ear, Nose and Throat (ENT) and dental procedures. Perioperative airway complications were encountered infrequently in the major craniofacial operations. Just over half of the incidents of supraglottic obstruction arose in children under the age of 2 years, which is not unexpected. We find it reassuring to have collected data that demonstrate that if supraglottic airway obstruction does occur, laryngoscopy and intubation are generally easy. It should be noted, however, that although surgical mid-face advancement improves the cosmetic appearance, it results in a marked deterioration of laryngoscopic view and this may cause unexpected difficulties (15,16).

Our data demonstrate that patients with Apert syndrome may require many anesthetics of relatively short duration. A large proportion of the anesthetics were of < 30 min and this explains the large proportion of cases where the patient was breathing spontaneously either with a face-mask or laryngeal mask airway.

In 52 of the anesthetic charts, there was no peripheral vascular access. This was a deliberate policy intended to preserve valuable vascular access sites during hand dressing changes. An intraosseous device was immediately available for all these cases, but was never required.

In our cohort of patients the perioperative problems occurred in 21 children (34%), which is a similar incidence to Elwood *et al.* (10) who reported respiratory complications in 33% of patients. Very few of the complications were serious and none resulted in cancellation of the procedure so it is important that a population of patients are not incorrectly labeled as 'high risk'. Nevertheless, a significant proportion of these children have obstructive sleep apnoea and may develop supraglottic airway obstruction on induction and emergence from anesthesia due to the mid-face anatomical abnormalities associated with this syndrome and the anesthetist must be prepared to deal with this.

Acknowledgments

We thank the craniofacial nurse specialists Andrea White and Kathy Truscott for their help obtaining the list of patients. The authors have no financial or other interests to declare.

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