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COMPLICATIONS RELATED TO ANAESTHESIA IN INFANTS AND CHILDREN

A Prospective Survey of 40240 Anaesthetics

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SUMMARY

A prospective survey of anaesthesia-related mortality and morbidity in infants and children was carried out in a representative sample of anaesthetics performed in 440 institutions chosen at random in France. A total of 40240 anaesthetics were administered to patients younger than 15 yr, 2103 (5%) involving infants (younger than 1 yr). Twenty-seven major complications related to anaesthesia occurred during or within 24 h of the anaesthesia—an incidence of 0.7 per 1000 anaesthetics. Nine, of which four were associated with cardiac arrest, were observed in infants, whereas in children there were 18 complications of which eight were associated with cardiac arrest, one with fatal outcome. The risk of complications was significantly higher ($P < 0.001$) in infants (4.3 per 1000) than in children (0.5 per 1000). Accidents observed in infants mainly occurred during maintenance of anaesthesia and were the result of respiratory failure. In children, circulatory failure was as frequent as respiratory failure and complications were observed almost equally during induction and maintenance and on recovery. The rate of complications increased significantly with the ASA score and the number of co-existing diseases. The incidence was also higher when a previous history of anaesthesia was present, when the procedure was an emergency, and when the duration of preoperative fasting was less than 8 h.

Epidemiological data concerning anaesthesia-related mortality and morbidity in children are few and are now largely outdated because of the many advances in the standard of anaesthetic practice [1–4]. These surveys involved teaching hospitals and gave a rough estimate of the overall risk but, since they were retrospective, did not permit the investigation of risk factors. In addition, they focused on deaths and cardiac arrests and did not include other life-threatening accidents.

Major anaesthetic complications occurring in children were assembled from a prospective survey of complications related to anaesthesia conducted in France between 1978 and 1982 and analysed. The overall rate and lethality of anaesthetic complications in children were assessed, and their causes and any attendant risk factors determined.

PATIENTS AND METHODS

Details of the methods utilized in this study have been published previously [5].

Four hundred and sixty-one institutions were chosen at random from the whole of France, including paediatric and general hospitals, and private institutions. Paediatric patients (younger than 15 yr) were admitted by 440 of them. In this prospective study, all anaesthetics, general and regional, delivered by or under the direction of certified anaesthetists, were considered, including those administered for radiological or endoscopic investigations. A questionnaire was completed by the anaesthetist for each anaesthetic.

A major complication was defined as any fatal

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or life-threatening accident or any incident producing severe sequelae, which occurred during, or within 24 h of, anaesthesia. Whether or not it appeared to be related to anaesthesia, a supplementary questionnaire was required to be completed. At the conclusion of each report, the contribution of anaesthesia to the complication was assessed, by the anaesthetist involved with the case, as "nil", "partial" or "total". All reports were then scrutinized by a National Committee of Assessors, including anaesthetists who held an academic position, which made its own assessment of the role of anaesthesia. Each case was finally assigned as "totally", "partially" or "not" related to anaesthesia—"total" when anaesthesia was the direct cause or a major contributory factor of the complication, and "partial" when the complication was primarily a result of the patient's disease or the surgical procedure, but an anaesthetic contribution could not be entirely excluded.

Complications related totally or partially to anaesthesia were classified according to the mechanism primarily responsible: failure of respiratory homeostasis, or failure of circulatory homeostasis. Within these groups, they were further subdivided according to the time of their occurrence: at induction of anaesthesia (within 10 min of the start of anaesthesia); maintenance of anaesthesia (until the end of the surgical procedure); post-anaesthetic period (up to 24 h after the end of surgery). As far as possible, complications classified were based on the cause presumed to be at the origin of the accident; for example, laryngospasm was not reported as a complication, since it was a symptom and not a cause. An exception was the group "sudden cardiac arrest", since the cause could not be established.

Risk factors studied were the patient's preoperative condition (ASA physical status, number of co-existing diseases, previous history of anaesthesia, duration of preoperative fasting), and whether the procedure was elective or emergency.

Results in infants (younger than 1 yr) were analysed separately from those of children (aged 1–14 yr), except for the study of risk factors because of the low frequency of complications. The incidence of complications in the paediatric group was compared with that in adults, assessed from the survey of Tiret and colleagues [5]. The Chi-square test was used for statistical comparison of the rates of complications in different groups. When expected frequencies were small, the exact probability was calculated.

RESULTS

During the survey, 40240 anaesthetics were administered to patients younger than 15 yr, 2103 (5%) to infants (< 1 yr). The types of procedure being undergone are summarized in table I. In the infant group, abdominal surgery was the most frequent procedure whereas, in children, ENT surgery was the most common procedure. Diagnostic investigations accounted for more than 10% of the procedures performed in infants.

Complications

In the 40240 procedures, 27 major complications related to anaesthesia occurred during or within 24 h of anaesthesia. Almost all (25) were deemed to be totally related to anaesthesia. Nine

TABLE I. *Types of procedure in infants (< 1 yr) and children (1–14 yr); percentage of total procedures (n) in each group*

	Infants ($n = 2103$)	Children ($n = 38137$)	Both ($n = 40240$)
ENT surgery	18.4	31.6	30.9
Abdominal surgery	28.5	25.0	25.2
Orthopaedic and trauma surgery	8.5	12.4	12.2
Male genital surgery	5.1	9.1	8.9
Diagnostic investigations	13.6	3.3	3.8
Oral surgery	1.0	3.9	3.7
Ophthalmological surgery	2.1	2.9	2.8
Urological surgery	1.6	0.9	1.0
Neurosurgery	4.3	0.5	0.7
Cardiovascular surgery	3.0	0.5	0.7
Miscellaneous	13.9	9.9	10.1

TABLE II. *Number of complications related to anaesthesia in infants (< 1 yr) and children (1–14 yr).* † *One death*

	Infants ($n = 2103$)	Children ($n = 38137$)	Both ($n = 40240$)
Cardiac arrest	4	8†	12
Other	5	10	15
Total	9	18	27

TABLE III. *Incidence (No. per 1000) of anaesthetic complications in infants and children, compared with results in adults (ref. [5]).* **$P < 0.01$; ***$P < 0.001$; *ns = not significant*

	All complications	Cardiac arrests	Deaths
Infants < 1 yr	4.3 ***	1.9 **	— ns
Children 1–14 yr	0.5	0.2	0.03
Total 0–14 yr	0.7 ***	0.3 **	0.02 ***
Adults ⩾ 15 yr	1.5	0.7	0.4

of these complications were observed in infants, four associated with cardiac arrest. In children, 18 complications were observed, eight associated with cardiac arrest. One had a fatal outcome (table II).

All complications were observed in patients undergoing general anaesthesia, but it must be noted that regional anaesthesia was used in only 0.5% of procedures. No complication was observed during cardiac surgery.

The rate of anaesthetic complications was significantly higher in infants (4.3 per 1000) than in children (0.5 per 1000) ($P < 0.001$). Patients younger than 15 yr had a significantly lower risk than adults. The same was true when considering only the complications associated with cardiac arrest or the deaths (table III).

Complications, and the time of their occurrence, are shown for infants and children in tables IV and V, respectively.

In infants, complications occurred mainly during the maintenance of anaesthesia (table IV), whereas in children, many complications occurred at induction or during the postanaesthetic period (table V). The delay in occurrence of postanaesthetic complications was short in most of the patients, six out of eight being observed within the first 1 h following the conclusion of surgery.

Of the nine accidents observed in infants, seven were respiratory complications. In children, respiratory complications were seen as frequently as circulatory complications.

Airway mismanagement (five patients). This term meant a wrong choice of airway management technique, presumed to be responsible for the complication. Included in this group are: lack of tracheal intubation (one patient); premature extubation (one); bronchospasm in one patient having an history of allergy and whose trachea was intubated; asphyxia during inhalation anaesthesia in two patients with upper airway tract anomalies.

Complication of intubation (four patients). This group included technical incidents of tracheal intubation. These were: right lung selective intubation (one); unintentional extubation (one); obstruction of tube by secretions (one); aspiration in one patient during intubation of the trachea.

Aspiration (four patients). Included in this group are cases of aspiration occurring in patients in whom the trachea was not being intubated.

TABLE IV. *Causes of anaesthetic complications and the time of their occurrence in infants (< 1 yr)*

	Time of occurrence		
	Induction	Maintenance	Recovery
Respiratory complications			
Airway mismanagement	1	2	—
Complication of intubation	—	2	—
Inhalation of vomit	—	1	1
Circulatory complications			
Sudden cardiac arrest	—	1	—
Acute pulmonary oedema	—	—	1
Total	1	6	2

TABLE V. *Causes of anaesthetic complications and the time of their occurrence in children (1–14 yr).* † *One death*

	Time of occurrence		
	Induction	Maintenance	Recovery
Respiratory complications			
Airway mismanagement	—	1	1
Complication of intubation	1	1	—
Inhalation of vomit	1	—	1
Respiratory depression	—	—	2†
Failure of equipment	1	—	—
Circulatory complications			
Sudden cardiac arrest	1	—	—
Halothane overdose	1	1	—
Anaphylactoid shock	2	1	—
Acute pulmonary oedema	—	—	1
Severe arrhythmias	—	1	1
Total	7	5	6

Although this complication should have been classified in the "airway mismanagement" group, it has been individualized because it represents a major matter of concern in anaesthesia. Two of these episodes occurred during anaesthesia and the other two during the recovery period.

Postoperative respiratory depression. In two patients classified in this group, narcotic analgesics had been administered, for which antagonists had not been used. One of these episodes led to the death of a child of 13 yr.

Failure of equipment (one patient). This event followed a wrong mounting of the ventilator valve.

Halothane overdose. One occurred during induction and another during maintenance of anaesthesia, in patients breathing spontaneously.

Anaphylactoid shock. Althesin was incriminated in one patient, suxamethonium in another and, in the third, the circulatory failure followed a blood transfusion.

Acute pulmonary oedema. This complication, in two patients, was the result of fluid overload.

Severe arrhythmia. This occurred during maintenance, in a child undergoing circumcision, when inadequate analgesia was incriminated by the anaesthetist; and at recovery, in a patient operated on for peritonitis with septic shock. An electrolyte imbalance might have been responsible for this latter accident, judged to be partially related to anaesthesia.

Cardiac arrest (two patients). In both patients, no obvious cause was reported by the anaesthetist involved with the case. One of these events was followed by mild neurological sequelae and the other was associated with pericarditis followed by complete recovery.

With the exception of cardiac arrest, an example of each of these complications is illustrated in greater detail in table VI.

Risk factors

The anaesthetic risk was closely related to the patient's preoperative condition. It increased markedly with ASA score (rate of complications > 10 per 1000 for patients ASA $\geqslant$ III) and with co-existing diseases (rate of complications > 20 per 1000 with three or more co-existing diseases) (table VII). Concurrent airway infection was present in two patients with complications. Hypovolaemia was mentioned in one patient with complications and anaemia in another. Other co-existing diseases were mainly congenital anomalies. Patients who had previously been anaes-

TABLE VI. *Cases illustrative of complications. sux. = Suxamethonium*

Complication	Age/sex	Weight (kg)	Co-existing diseases	ASA status	Preoperative diagnosis	Anaesthesia	Time of occurrence	Comment	Outcome
Airway mis-management	5 month/M	6	Bronchitis	II	Inguinal hernia +ectopic testis	I.v. + halothane + N_2O No tracheal intubation	Maintenance	Laryngospasm Bradycardia Cardiac arrest	Recovered
Complication of intubation	1 day/M	4	No	IIIE	Anal atresia	Halothane + N_2O + tubocurarine narcotic analgesic	Maintenance	Right lung selective intubation	Recovered
Inhalation	7 yr/M	23	No	I	Appendicitis	I.v. + halothane + N_2O No tracheal intubation	Recovery	Laryngospasm + bronchospasm (full stomach)	Recovered
Respiratory depression	13 yr/M	36	No	I	Fractured wrist (reintervention)	I.v. + N_2O + sux. + narcotic analgesic + neuroleptic	Recovery	Coma discovered in ward, 4 h after end of surgery	Died
Failure of equipment	8 yr/F	23	No	I	Congenital hip dysplasia	I.v. + halothane + N_2O + sux. + narcotic analgesic	Induction	Wrong mounting of ventilator valve Cardiac arrest	Recovered
Sudden cardiac arrest	1 month/F	5	Previous hypocal-caemia	II	Hip osteoarthritis	Halothane + N_2O	Maintenance	?	Mild neurological sequelae
Halothane overdose	1 yr/F	7	Multiple congenital anomalies	IV	Renal dysplasia	Sux. + 3% halothane Spontaneous ventilation	Maintenance	Ventricular arrhythmias Circulatory arrest	Recovered
Anaphylactoid shock	14 yr/M	66	No	I	Hirschprung's disease	I.v + N_2O + sux. + tubocurarine + neuroleptic + narcotic analgesic	Induction	Shock to Althesin	Recovered
Acute pulmonary oedema	10 yr/M	28	Hypovolaemia Hypothermia	IIE	Open fractured leg	I.v. + halothane + N_2O + sux. + narcotic analgesic	Recovery	Preoperative fluid overload Insufficient rewarming	Recovered
Arrhythmia	2 yr/M	12	Septic shock	IIIE	Peritonitis	I.v. + halothane + N_2O + tubocurarine	Recovery	Electrolyte imbalance?	Recovered

TABLE VII. *Incidence of anaesthetic complications (number, and rate per 1000) according to risk factors (infants and children grouped together).* † *Group ASA I* v. *groups ASA II, III, IV + V.* § *Groups with 0 or 1 co-existing disease* v. *groups with 2 or ⩾ 3 co-existing diseases*

	No. anaesthetics	Major complications		P
		No.	Rate	
ASA class				
I	36 903	14	0.4	
II	1 461	5	3.4	0.001†
III	518	6	11.6	
IV + V	122	2	16.4	
No. co-existing diseases				
0	36 544	18	0.5	
1	3 064	4	1.3	
2	490	2	4.1	0.001§
⩾ 3	142	3	21.1	
Previous anaesthetic				
No	27 517	14	0.5	0.05
Yes	11 343	13	1.1	
Duration of preoperative fasting (h)				
< 8	5 189	8	1.5	0.05
⩾ 8	34 067	19	0.6	
Emergency				
No	33 391	18	0.5	0.05
Yes	5 918	9	1.5	

thetized were more prone to complications than those undergoing a first anaesthetic. Full stomach (defined as a preoperative fasting period of less than 8 h) was also associated with a higher complication rate. Complications appeared three times more frequently during emergency than during elective procedures (table VII).

DISCUSSION

We have previously commented on the design of this study [5], but certain points are worth re-emphasizing. There is a possible underestimation of non-lethal complications, since the accuracy of notification could be confirmed only for the deaths. The survey did not include complications occurring after the 24 h. Because of the absence of co-existing diseases in most of the paediatric patients, these delayed complications are even less frequent in children than in adults.

The mortality rate observed in this study was very low (1 in 40000). Smith [6] gave similar figures, provided by two paediatric institutions: no death in 37000 cases of tonsillectomy, one anaesthetic death in 29000 procedures of all types. The fact that anaesthetic mortality has decreased markedly in the paediatric population during the past 20 years [1,2] is sufficient reason for studies of this type to be extended to include morbidity. The rate of cardiac arrests in our study (0.3 per 1000) was lower than in the survey reported in 1961 by Rackow, Salanitre and Green [1] (0.7 per 1000), but it was not different from that reported by Salem and colleagues in 1975 [4]. In keeping with previous reports [1,7,8], the risk of complications was higher in infants than in children.

As a group, patients younger than 15 yr had a morbidity and mortality risk lower than adults—the opposite of the earlier results [1,2]. This reversal of trends probably reflects the improvements in paediatric anaesthesia during the past 20 years. However, the risk of anaesthetic cardiac arrests has been observed to be greater in patients younger than 12 yr than in adults, although most occurred in infants [9].

Comparison of accidents in infants with those in children revealed marked differences. Whereas complications observed in infants occurred mainly during the maintenance of anaesthesia and were the result of respiratory failure, circulatory failure was as frequent as respiratory failure in children. In addition, accidents were divided almost equally during the three periods of anaesthesia in the > 1 yr paediatric population. The fact that the only death occurred during the recovery period emphasizes again that this period is particularly critical [5].

This study highlighted the predominant role played by the patient's preoperative condition in the occurrence of complications. However, in retrospect, most of the complications seemed avoidable.

Although interpretation of the data reported here must take into account problems specific to clinical practice in France, this study represents the first prospective study of anaesthetic morbidity in the paediatric age group.

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