

Respiratory complications associated with tracheal intubation and extubation†

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Summary

We conducted a prospective survey on the incidence of respiratory complications associated with tracheal intubation and extubation in 1005 patients who underwent elective general anaesthesia over a 4-month period. During induction of anaesthesia, respiratory complications occurred in 46 patients (4.6%; 95% confidence limits (CL): 3.3, 5.9%). The common complications were coughing (1.5%) and difficult ventilation through a facemask (1.4%). Tracheal intubation was difficult in eight patients (0.8%). Complications occurred immediately after tracheal extubation in 127 patients (12.6%; 95% CL: 10.6, 14.7) and in the recovery room in 95 patients (9.5%; 95% CL: 7.6, 11.3%). The common complications immediately after extubation were coughing (6.6%) and oxygen desaturation ($Sa_{O_2} < 90\%$) (2.4%), and in the recovery room, airway obstruction (3.8%) and coughing (3.1%). The incidence of complications was significantly higher immediately after tracheal extubation than during induction of anaesthesia ($P < 0.001$). Even when all incidents of coughing that occurred after tracheal extubation were disregarded as a complication, the overall incidence was still higher immediately after extubation (7.4%) than during induction of anaesthesia ($P < 0.01$). We conclude that the incidence of respiratory complications associated with tracheal extubation may be higher than that during tracheal intubation. (*Br. J. Anaesth.* 1998; 80: 767–775)

Keywords: complications extubation tracheal; complications intubation tracheal; complications respiratory incidence

The prediction, incidence and mechanisms of difficult tracheal intubation have been extensively studied.^{1–5} The incidence and detection of inadvertent oesophageal intubation have also been reported.^{6,7} However, the incidence of other respiratory complications that occur during induction of anaesthesia has not been studied.

Respiratory complications may be frequent during and after tracheal extubation.^{8,9} There have been several reports of the incidence of respiratory complications occurring in the recovery room,^{10–15} but we have found no comprehensive report of the incidence of complications immediately after tracheal extubation.

The main aims of the present study were therefore to establish the incidence of respiratory complications during induction of anaesthesia, and during and after emergence from anaesthesia, and to

examine if some factors, such as difference in sex, age, ease of laryngoscopy or depth of anaesthesia during tracheal extubation, influenced the incidence of respiratory complications.

Patients and methods

We conducted a prospective survey to ascertain the incidence of respiratory complications associated with tracheal intubation and extubation. The chairman of the local Ethics Committee informed us that, because of the nature of the study, submission of a protocol to the Committee was unnecessary. The study was carried out at the main operating theatres of the University Hospital of Wales, where about 12 000 surgical cases are dealt with each year; no obstetric, orthopaedic or thoracic surgery was performed, nor was there any day surgery.

In a preliminary unpublished study, we obtained data for about 250 patients on respiratory complications that occurred during emergence from anaesthesia. On the basis of these findings, we developed a formal data-recording form (fig. 1) and estimated the required number of patients for analysis. Data from this preliminary study were not included in the analysis.

We attempted to obtain data from all patients who underwent elective surgery, in whom the trachea was intubated and extubated in the operating theatre. After operation patients were transferred to the recovery room while oxygen 61 min^{-1} was supplied through a Hudson facemask; in the recovery room, their condition was monitored by recovery nurses, who decided when to discharge patients to the ward. Data were not obtained when patients were transferred directly to the intensive care unit or when tracheostomy was performed before or during operation.

The incidence of difficult tracheal intubation is reported to be less than 2%,^{6,10,16,17} and that of laryngospasm to be less than 1%.^{6,10,17,18} The incidence of oesophageal intubation would also be less than 1%.⁶ Therefore we estimated that the incidence of respiratory complications during induction of anaes-

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Grade Consultant , Senior Registrar , Registrar , SHO

Operation: _____

Weight: _____ kg (or _____ stone)

I. Preoperative assessment

- ASA physical status: 1 , 2 , 3 , 4 , 5 , E
- Mallampati's class: 1 , 2 , 3 , 4
- Does the patient have any airway problems?
Yes , No (If yes, describe the problem: _____)

II. Tracheal intubation

- Induction: Awake , Intravenous , Inhalational , Rapid-sequence (Crash)
- Were there any complications during induction?
None , Ventilation difficulty through a facemask , Laryngospasm
Desaturation (< 95%) (lowest value: _____ %)
Coughing , Gagging , Vomiting , Aspiration
Other _____
- Cormack and Lehane's grade (the view of the glottis at laryngoscopy):
1 , 2 , 3 , 4 (Definition: see back of the page)
- Difficulty at tracheal intubation:
Easy , Moderately difficult , Difficult
- Was other technique used at intubation?
Yes , No (If yes, Bougie , Fibrescope , Other _____)
- Muscle relaxant: Not used , Suxamethonium ,
Atracurium , Pancuronium , Vecuronium , Other _____

III. Maintenance of general anaesthesia

- Anaesthetic agent: N₂O , Isoflurane , Sevoflurane , Enflurane , Halothane , TTVA

IV. Tracheal extubation

- Reversal agents: Not used , Atropine , Glycopyrrolate , Neostigmine
- Was a nerve stimulator used at extubation?
Yes , No
- Level of anaesthesia at extubation
Awake , Light anaesthesia , Deep anaesthesia
- Was the trachea extubated in the theatre?
Yes , No
- Were there any complications at extubation?
None , Coughing , Breath holding , Airway obstruction ,
Laryngospasm , Desaturation (< 95%) (lowest value: _____ %)
Inadequate reversal , Apnoea , Vomiting , Aspiration
Other _____

If there was any problem, how was it managed?
Oxygen therapy , Jaw support , Airway used ,
Reversal drugs , Re-intubation , Other _____

V. To Recovery Nurse

- Were there any complications in the recovery room?
None , Coughing , Breath holding , Airway obstruction ,
Laryngospasm , Desaturation (< 95%) (lowest value: _____ %)
Inadequate reversal , Apnoea , Vomiting , Aspiration
Other _____

If there was any problem, how was it managed?
Oxygen therapy , Jaw support , Airway used
Reversal drugs , Re-intubation
Other _____

Was an anaesthetist required?
Yes , No

Figure 1 Data-recording form. Some sections (title; date; definition and figures for the view of the oropharynx and the glottis) are omitted here.

thesia would be up to 5%. In the preliminary observations of 250 patients, the incidence of complications after tracheal extubation was 10–15%. To detect this difference in incidence of complications at the times of induction of anaesthesia and extubation, with $P < 0.05$ and a power of 90%, 500–1000 patients would be required.¹⁹

DATA-RECORDING FORM

The data-recording form was designed to fit on both sides of a sheet of A4 paper (fig. 1), and had five main sections, to record: (I) information obtained at preoperative assessment; (II) details about induction of anaesthesia; (III) methods by which general anaesthesia was maintained; (IV) details about tracheal

Table 1 Relationship between preoperative view of the oropharynx and view of the glottis at laryngoscopy. Data from 858 patients are shown; the view of the oropharynx was not examined in the remaining 147 patients (see text.) *In 15 patients the trachea was intubated without the use of a laryngoscope (fibrescope-aided tracheal intubation)

View of the oropharynx	View of the glottis					Total (n, %)
	Grade 1 (n, %)	Grade 2 (n, %)	Grade 3 (n, %)	Grade 4 (n, %)	Not examined* (n, %)	
Class 1	472	58	9	0	7	546 (63.6)
Class 2	121	82	33	1	6	243 (28.3)
Class 3	20	17	20	2	1	60 (7.0)
Class 4	2	2	4	0	1	9 (1.0)
Total	615 (71.7)	159 (18.5)	66 (7.7)	3 (0.3)	15 (1.7)	858 (100.0)

extubation; (V) respiratory complications and treatments that occurred in the recovery room.

The view of the oropharynx was classified according to Mallampati and colleagues¹ and Samsoun and Young²⁰; the view of the glottis at laryngoscopy was graded according to Cormack and Lehane.²¹ Definitions and schematic diagrams were provided for classification of the view of the oropharynx and of the glottis, because anaesthetists' understanding of the scoring is not always accurate.²² No definition was provided for difficult ventilation through a facemask or difficult tracheal intubation, and no grading of the degree of difficulty in ventilation through a facemask was required.

The anaesthetists were asked to fill in the first four sections and the recovery nurses the last section. Each section required a tick in at least one box; for example, the section for complications included a box "None". This enabled us to detect errors of omission (no tick in any box) and commission (ticks in the "None" box and in a complication box); errors were rectified after collection of the data sheet (see below).

DATA COLLECTION

We aimed to collect data from 1000 patients and estimated that this would take about 4 months. The study was done during the elective lists on Mondays to Fridays between November 4, 1996 and March 10, 1997; however, data were not collected between December 20 and January 5 because of the possibil-

Table 2 Ranked incidence of preoperative problems of the airway. *Down's syndrome, Pierre Robin sequence (previously called Pierre Robin syndrome) and acromegaly

Problem	n (%)
Difficult view of the oropharynx	69 (6.9)
Limited extension of the neck	17 (1.7)
Asthma	14 (1.4)
Obstructed nasal passage	12 (1.2)
Fragile or protrusive teeth	10 (1.0)
Hoarseness	9 (0.9)
Short neck	6 (0.6)
Deviation of the trachea	5 (0.5)
Limited opening of the mouth	4 (0.4)
Receding jaw	3 (0.3)
Gastro-oesophageal reflux	3 (0.3)
Anomalies* with suspected difficult airway	3 (0.3)
Previous difficult intubation	2 (0.2)
History of tracheostomy	2 (0.2)
Cleft lip and palate	2 (0.2)
Vocal cord palsy	2 (0.2)
Oropharyngeal cyst	1 (0.1)
Bronchopulmonary dysplasia	1 (0.1)
Total (one or more problems)	145 (14.4)

ity of irregular lists during this period. Data collection was not carried out when no investigator could check the data sheets on the day of collection.

Before the start of the survey, the aims were explained to each anaesthetist and recovery nurse. The method of completing the data sheet was also explained. Anaesthetists and nurses were able to refuse to participate; they were also able to refuse to collect a part of the data if they had objections — this occurred only for preoperative assessment of the view of the oropharynx (see Results).

An investigator handed data sheets to each anaesthetist before each morning and afternoon list to minimize omission of patients. When the patient was transferred to the recovery room after the operation, an investigator ensured that the data sheet was handed to the recovery nurse. When the nurse had completed the data sheet, the investigator collected it and checked the sheet. If there were omissions — except for body weight (see below) — the investigator contacted the anaesthetist or nurse involved as soon as possible on the same day and rectified the omissions.

The total number of patients admitted to the operating theatre and transferred to the recovery room was obtained from (1) a registration list that records all patients who have been transferred to the recovery room, and (2) a computer recording system²³ that stores all anaesthetic records submitted to our department. The numbers of patients for each type of anaesthesia (general, regional, local) and each method of airway management (for example, tracheal intubation, use of laryngeal mask airway) were obtained from the anaesthetic records.

DATA ANALYSIS

The proportions in each grade, category or type for the following factors were recorded: sex, age group, ASA physical status, grade of anaesthetist, type of operation, type of anaesthesia (general, regional or local), type of airway (for example, a tracheal tube or laryngeal mask), view of the oropharynx, view of the glottis, difficulty in tracheal intubation, type of anaesthetic agent, type of neuromuscular blocking agent, and depth of anaesthesia at tracheal extubation.

The incidence of respiratory complications during the following three periods was obtained: (1) induction of anaesthesia; (2) immediately after tracheal extubation (in the operating theatre); (3) shortly after extubation (during transfer of the patients from the operating theatre to the recovery room and in the recovery room).

Table 3 Ranked incidence of respiratory complications associated with tracheal intubation and extubation in 1005 patients

Complications occurring during induction of anaesthesia	n (%)	Complications occurring immediately after extubation (in operating theatre)	n (%)	Complications occurring shortly after extubation (in recovery room)	n (%)
Coughing	15 (1.5)	Coughing	66 (6.6)	Airway obstruction	38 (3.8)
Difficult ventilation	14 (1.4)	Desaturation (Sp _O ₂ <90%)	24 (2.4)	Coughing	31 (3.1)
Desaturation (Sp _O ₂ <90%)	11 (1.1)	Breath-holding	20 (2.0)	Desaturation (Sp _O ₂ <90%)	22 (2.2)
Difficult intubation	8 (0.8)	Airway obstruction	19 (1.9)	Laryngospasm	8 (0.8)
Laryngospasm	4 (0.4)	Laryngospasm	17 (1.7)	Apnoea, hypoventilation	8 (0.8)
Oesophageal intubation	3 (0.3)	Apnoea, hypoventilation	9 (0.9)	Vomiting	7 (0.7)
Gagging	1 (0.1)	Inadequate reversal	5 (0.5)	Breath-holding	3 (0.3)
		Vomiting	3 (0.3)	Inadequate reversal	3 (0.3)
		Masseter spasm	1 (0.1)	Bronchospasm	2 (0.2)
Patients experiencing one or more complication	46 (4.6)		126 (12.5)		95 (9.5)
95% confidence limits	3.3, 5.9%		10.5, 14.6%		7.6, 11.3%

The view of the oropharynx was defined as difficult when classed as 3 or 4.^{5,20} Laryngoscopy was defined as difficult when the view of the glottis was graded 3 or 4.^{3,24} Difficulty in laryngoscopy was not regarded as a complication unless tracheal intubation was difficult; difficulty with tracheal intubation was regarded as a complication only when anaesthetists recorded it as "difficult" (that is, not moderately difficult or easy).

STATISTICAL ANALYSIS

The chi-square test for trend was used to test the relationship between ease of viewing the glottis with the quality of the preoperative view of the oropharynx, in terms of the view of the oropharynx (classes 1 and 2) *vs* obscured view (classes 3 and 4). Grades 3 and 4 of the view of the glottis were also pooled to avoid expected frequencies of less than 5.²⁵

Fisher's exact test was used to compare the total incidence of complications occurring during induction of anaesthesia with that immediately after tracheal extubation. No hypothesis test was used for complications that occurred shortly after tracheal extubation, as these included occurrence over a considerably longer period than the other two circumstances. $P < 0.05$ was considered significant. If the P was much smaller than 0.001, it was expressed as $P < < 0.001$.

The 95% confidence limits (CL) for the incidences of complications at each period were calculated.²⁶ For respiratory complications during induction of anaesthesia and after tracheal extubation, the relative risk and 95% CL were calculated for the following predetermined set of factors: sex difference, age difference (15 yr or younger *vs* older), ASA physical status (I and II *vs* III and IV), the grade of anaesthetist

(consultants and senior registrars *vs* registrars and senior house officers), the view of the oropharynx (classes 1 and 2 *vs* 3 and 4), the presence or absence of preoperative airway problems, and depth of anaesthesia during tracheal extubation (deep *vs* awake). We could not obtain accurate data for patients' weight and height, because they were not routinely measured before operation; therefore it was not possible to classify patients as obese or non-obese. Nevertheless, we arbitrarily classified patients of 16 yr or older into two groups (90 kg or heavier and less than 90 kg) and included this factor in the analysis.

Results

DATA COLLECTION, TYPE OF ANAESTHESIA AND PATIENT CHARACTERISTICS

Sixty five of 68 anaesthetists who were working at the main operating theatres during the study period agreed to participate in the study.

During the 4-month period, 1774 patients underwent elective surgery and were admitted to the recovery room. The trachea was intubated in 1200 patients, who were the subjects for data collection. Data for 1011 patients were obtained, but six sets of data were withdrawn from the analysis because of omissions not detected by an investigator on the day of collection. Therefore 1005 data sets were used for analysis (collection rate: 83.8%).

PREOPERATIVE AIRWAY PROBLEMS

During the preoperative period, no view of the oropharynx was obtained in 147 patients (14.6%), because it was the policy of the anaesthetist or because the patient was too young to co-operate (for

Table 4 Ease of tracheal intubation related to grade of view of the glottis at laryngoscopy and in patients in whom other techniques were used for tracheal intubation

Technique (no. of patients)	Easy n (%)	Moderately difficult n (%)	Difficult n (%)
Laryngoscopy (n = 958)			
Grade 1 (n = 693)	678 (67.5)	15 (1.5)	0
Grade 2 (n = 194)	149 (14.8)	45 (4.5)	0
Grade 3 (n = 68)	13 (1.3)	50 (5.0)	5 (0.5)
Grade 4 (n = 3)	1 (0.1)	1 (0.1)	1 (0.1)
Fibreoptic bronchoscopy (n = 45)	39 (3.9)	4 (0.4)	2 (0.2)
Retrograde method (n = 1)	1 (0.1)	0	0
Blind nasal method (n = 1)	1 (0.1)	0	0
Total (n = 1005)	882 (87.8)	115 (11.4)	8 (0.8)

Table 5 Incidence of respiratory complications during induction of anaesthesia and after tracheal extubation in 1005 patients according to sex, age group, ASA physical status, grade of anaesthetist, view of oropharynx and presence or absence of preoperative airway problems, and incidence of complications during emergence from anaesthesia according to anaesthetic method, muscle relaxant and level of anaesthesia at tracheal extubation. †Includes patients aged 16 yr or older whose weights were described. ‡Does not include patients in whom view of the oropharynx was grade 3 or 4 but no other airway problems were found. *Indicates marked differences between groups (see table 6). CL, confidence limits

Factors	Complications during induction of anaesthesia <i>n</i> (%) (95% CL)	Complications during emergences from anaesthesia		
		Immediately after extubation <i>n</i> (%)	Shortly after extubation <i>n</i> (%)	Total of either or both <i>n</i> (%) (95% CL)
Sex				
Male (<i>n</i> = 457)	38 (6.1) (3.9, 8.3)*	62 (13.6)	50 (13.6)	103 (22.5) (18.7, 26.4)*
Female (<i>n</i> = 548)	18 (3.3) (1.8, 4.8)*	64 (11.7)	45 (8.2)	97 (17.7) (14.5, 20.9)*
Age (yr)				
< 1 (<i>n</i> = 28)	2 (7.1) (0, 16.7)	1 (3.6)	0	1 (3.6) (0, 10.4)
1–9 (<i>n</i> = 37)	2 (5.4) (0, 12.7)	7 (18.9)	3 (8.1)	10 (27.0) (12.7, 41.3)
10–15 (<i>n</i> = 31)	1 (3.2) (0, 9.4)	1 (3.2)	2 (6.5)	3 (9.7) (0, 20.0)
16–19 (<i>n</i> = 33)	1 (3.0) (0, 8.9)	4 (12.1)	4 (12.1)	8 (24.2) (9.6, 38.9)
20–39 (<i>n</i> = 234)	6 (2.6) (0.5, 4.6)	35 (15.0)	20 (8.5)	52 (22.2) (16.9, 27.5)
40–59 (<i>n</i> = 327)	17 (5.2) (2.8, 7.6)	46 (14.1)	35 (10.7)	70 (21.4) (17.0, 25.9)
60–79 (<i>n</i> = 279)	17 (6.1) (3.3, 8.9)	31 (11.1)	28 (10.0)	52 (18.6) (14.1, 23.2)
≥ 80 (<i>n</i> = 36)	0	1 (2.8)	3 (8.3)	4 (11.1) (0.8, 21.4)
Weight (kg)†				
< 90 (<i>n</i> = 726)	22 (3.0) (1.8, 4.3)*	86 (11.8)	69 (9.5)	140 (19.3) (16.4, 22.2)
≥ 90 (<i>n</i> = 137)	14 (10.2) (5.1, 15.3)*	27 (19.7)	16 (11.7)	37 (27.0) (19.6, 34.4)
ASA physical status				
I or II (<i>n</i> = 772)	33 (4.3) (2.8, 5.7)	95 (12.3)	67 (8.7)	151 (19.6) (16.8, 22.4)
III or IV (<i>n</i> = 233)	13 (5.6) (2.6, 8.5)	31 (13.3)	28 (12.0)	49 (21.0) (15.8, 26.3)
Grade of anaesthetist				
Consultant (<i>n</i> = 576)	25 (4.3) (2.7, 6.0)	66 (11.5)	63 (10.9)	112 (19.4) (16.2, 22.7)
Senior registrar (<i>n</i> = 228)	9 (3.9) (1.4, 6.5)	27 (11.8)	20 (8.8)	44 (19.3) (14.2, 24.4)
Registrar or senior house officer (<i>n</i> = 201)	12 (6.0) (2.7, 9.2)	33 (16.4)	12 (6.0)	44 (21.9) (16.2, 27.6)
Preoperative view of the oropharynx				
Clear (grade 1 + 2) (<i>n</i> = 789)	23 (2.9) (1.7, 4.1)*	94 (11.9)	69 (8.7)	149 (18.9) (16.2, 21.6)
Obscure (grade 3 + 4) (<i>n</i> = 69)	10 (14.5) (6.2, 22.8)*	10 (14.5)	9 (13.0)	16 (23.2) (13.2, 33.1)
Preoperative airway problems‡				
Present (<i>n</i> = 94)	12 (12.8) (6.0, 19.5)*	14 (14.9)	10 (10.6)	20 (21.3) (13.0, 29.6)
Absent (<i>n</i> = 911)	34 (3.7) (2.5, 5.0)*	112 (12.3)	85 (9.3)	180 (19.8) (17.2, 22.3)
Anaesthetic method				
Isoflurane (<i>n</i> = 792)	—	93 (11.7)	77 (9.7)	153 (19.3) (16.6, 22.1)
Sevoflurane (<i>n</i> = 108)	—	19 (17.6)	4 (3.7)	22 (20.4) (12.8, 28.0)
Enflurane (<i>n</i> = 73)	—	12 (16.4)	10 (13.7)	21 (28.8) (18.4, 33.2)
Total intravenous anaesthesia (<i>n</i> = 32)	—	2 (6.3)	4 (12.5)	4 (12.5) (1.0, 24.0)
Muscle relaxant used during operation				
Not used (<i>n</i> = 8)	—	1 (12.5)	1 (12.5)	1 (12.5) (0, 35.4)
Suxamethonium (<i>n</i> = 55)	—	8 (14.5)	13 (23.6)	19 (34.5) (22.0, 47.1)
Vecuronium (<i>n</i> = 544)	—	61 (11.2)	42 (7.7)	96 (17.6) (14.4, 20.9)
Atracurium (<i>n</i> = 344)	—	45 (13.1)	35 (10.2)	71 (20.6) (16.4, 24.9)
Rocuronium (<i>n</i> = 42)	—	9 (21.4)	4 (9.5)	11 (26.2) (12.9, 39.5)
Pancuronium (<i>n</i> = 12)	—	2 (16.7)	0	2 (16.7) (0, 37.8)
Level of anaesthesia at tracheal extubation				
Deep (<i>n</i> = 202)	—	36 (17.8)	32 (15.8)	60 (29.7) (23.4, 36.0)*
Light (<i>n</i> = 348)	—	44 (12.6)	31 (8.9)	70 (20.1) (15.9, 24.3)
Awake (<i>n</i> = 455)	—	46 (10.1)	32 (7.0)	70 (15.4) (12.1, 18.7)*
Total (<i>n</i> = 1005)	46 (4.6) (3.3, 5.9)	126 (12.5)	95 (9.5)	200 (19.9) (17.4, 22.4)

example, infants). In the remaining 858 patients, the view of the oropharynx was difficult (class 3 or 4) in 69 patients (8%) (table 1). In total, airway problems were noted in 145 of 1005 patients (14.4%) before operation (table 2).

COMPLICATIONS DURING INDUCTION OF ANAESTHESIA

Respiratory complications occurred in 46 of 1005 patients (4.6%) during induction of anaesthesia (table 3).

Difficulty in ventilation through a facemask

Ventilation through a facemask was difficult in 14 of 1005 patients (1.4%). In six of these 14 patients, airway problems were detected before induction of anaesthesia (class 3 view of the oropharynx; limited movement of the head and neck; short neck and obstruction of the nasal passage). Desaturation

occurred in two of 14 patients (arterial haemoglobin oxygen saturation 85 and 65%, respectively), in one of whom an airway problem ("short neck") was recognized before anaesthesia. A retrograde method was used in one patient, because a difficult tracheal intubation had been predicted preoperatively (limited extension of the head and neck); in spite of difficult ventilation through a facemask, retrograde tracheal intubation succeeded within a few minutes without causing hypoxaemia. A laryngoscope was used for tracheal intubation in the remaining 13 patients, and laryngoscopy was difficult in only two patients (grade 3 in each case).

Difficulty in laryngoscopy and tracheal intubation

Laryngoscopy was difficult (grade 3 or 4) in 71 of 958 patients (7.4%) (table 4), but desaturation occurred in only two of them. In 32 of these 71 patients, airway problems were identified before

Table 6 Relative risks for factors for which the lower limit of 95% confidence intervals is equal to or greater than 1.0. †Includes patients aged 16 yr or older whose weights were described. ‡Does not include patients in whom the view of the oropharynx was class 3 or 4 but no other airway problems were found

Factor	Relative risk of respiratory complications	
	Induction of anaesthesia	Emergence from anaesthesia
Sex (male/female)	1.9 [1.1, 3.3]	1.3 [1.0, 1.6]
Weight† (≥ 90 kg / < 90 kg)	3.4 [1.8, 6.4]	—
Preoperative view of the oropharynx (clear (class 1 or 2)/obscure (3 or 4))	5.0 [2.5, 10.0]	—
Preoperative airway problems‡ (present/absent)	3.8 [2.2, 6.7]	—
Depth of anaesthesia at tracheal extubation ("deep"/awake)	—	1.9 [1.4, 2.6]

Table 7 Incidence of one or more respiratory complications after tracheal extubation according to level of anaesthesia at tracheal extubation and type of operation

Type of operation	No. of patients experiencing respiratory complications			
	Awake (n, %)	Light anaesthesia (n, %)	Deep anaesthesia (n, %)	Total no.
Neurosurgery (n = 176)	6/70 (8.6)	11/38 (28.9)	21/68 (30.9)	38/176 (21.6)
Eye, ear, nose and throat, dental (n = 293)	30/126 (23.8)	20/101 (19.8)	23/66 (34.8)	73/293 (24.9)
Neck and breast (n = 134)	8/56 (14.3)	9/46 (19.6)	9/32 (28.1)	26/134 (19.4)
Abdominal, renal and major vascular (n = 278)	16/129 (12.4)	21/25 (16.8)	4/24 (16.7)	41/278 (14.7)
Genitourinary, perineal and others (n = 124)	10/74 (13.5)	9/38 (23.7)	3/12 (25.0)	22/124 (17.7)
Total (n = 1005)	70/455 (15.4)	70/348 (20.1)	60/202 (29.7)	200/1005 (19.9)

operation. Tracheal intubation was difficult in eight patients (0.8%) (table 3); difficulty had been predicted preoperatively in five of them.

In 117 patients in whom tracheal intubation using a laryngoscope was difficult or moderately difficult, the trachea was intubated without the aid of another device in 53 patients, and with the aid of a gum elastic bougie in the remaining 64 patients. Tracheal intubation was successful in all patients.

There was a significant association between the preoperative view of the oropharynx and the view of the glottis at laryngoscopy (chi-square test for trend: $P < < 0.001$) (table 1).

Complications associated with fibrescope-aided tracheal intubation

A fibreoptic bronchoscope was used for tracheal intubation in 45 patients, of whom four experienced respiratory complications: coughing and gagging occurred in one patient, and desaturation in two anaesthetized and one sedated patient.

Oesophageal intubation

Oesophageal intubation occurred in three patients: tracheal intubation using a laryngoscope was moderately difficult in two of these patients and difficult in the third.

COMPLICATIONS AFTER TRACHEAL EXTUBATION

Respiratory complications occurred in 127 patients (12.6%) immediately after tracheal extubation and in 95 patients (9.5%) shortly after (table 3); overall, one or more respiratory complication occurred in 195 of 1005 patients (19.4%) after tracheal extubation.

The incidence of complications immediately after tracheal extubation was significantly higher than that during induction of anaesthesia ($P < < 0.001$).

FACTORS THAT AFFECT RESPIRATORY COMPLICATIONS

The incidence of respiratory complications for each factor is shown in detail in table 5. The relative risks with 95% confidence limits (table 6) showed that a few factors significantly affected the incidence of respiratory complications (CL for the relative risk exceeded 1.0) during induction of, or emergence from, anaesthesia. First, during both induction of anaesthesia and emergence from anaesthesia, the risks were greater in males than in females. Second, as expected, during induction of anaesthesia the risk of respiratory complications was greater when the view of the oropharynx was not clear or airway problems were found preoperatively; however, during emergence from anaesthesia, this factor did not affect the risk of complications (table 6). Third, the risk was greater in patients who were 90 kg or heavier than in those who were lighter than 90 kg. Last, complications were more likely if the trachea was extubated while the patient was still deeply anaesthetized rather than after the patient had regained consciousness (table 6).

The last difference might have reflected different populations between these two groups (awake vs deep). However, this seems unlikely, as the incidence of complications after tracheal extubation was generally greater in anaesthetized patients than awake patients, regardless of the type of operation (table 7).

Discussion

COMPLICATIONS DURING INDUCTION OF ANAESTHESIA

Several complications occurred during induction of anaesthesia, the incidence of each being up to 1.5%.

Difficulty in ventilation through a facemask, which could be life-threatening, was as frequent as difficulty in tracheal intubation during induction of anaesthesia (table 3). As with previous studies,^{1,3-5} the incidence of difficult laryngoscopy or difficult

tracheal intubation was significantly higher when it was difficult to see the oropharynx clearly preoperatively (table 1). In eight patients in whom tracheal intubation was difficult, airway problems were detected in five patients before induction of anaesthesia. However, in more than 50% of patients in whom ventilation through a facemask was difficult, no airway problems had been detected before induction of anaesthesia.

COMPLICATIONS AFTER TRACHEAL EXTUBATION

Respiratory complications were considerably more frequent immediately after tracheal extubation than during induction of anaesthesia (table 3). The most common was coughing (6.6%), but potentially serious complications, such as desaturation and laryngospasm, also occurred more often than during induction of anaesthesia (table 3).

Coughing is usually not a complication in itself, as it is a physiological response to protect the airway from aspiration. However, coughing may increase arterial pressure, heart rate and intraocular or intracranial pressure,^{27,28} and ineffective or persistent coughing might be associated with complications such as laryngospasm. It may be reasonable to regard coughing as a complication if other complications, such as decrease in Sp_{O₂}, laryngospasm or airway obstruction, are associated with coughing. In the present study, coughing was associated with other respiratory complications in 13 of 66 patients (20%) immediately after tracheal extubation and in 5 of 31 patients (16%) shortly after tracheal extubation. Nevertheless, even when all postoperative coughing is disregarded as a complication, the overall incidence of respiratory complications is still considerably higher, both immediately after tracheal extubation (7.4%; 95% CL: 6.0, 9.3) or shortly after extubation (6.9%; 95% CL: 5.5, 8.6) than during induction of anaesthesia. The incidence immediately after tracheal extubation was still significantly higher than during induction ($P < 0.01$).

Surprisingly, the incidence of respiratory complications remained high in the recovery room (table 3). Airway obstruction, apnoea or laryngobronchospasm occurred more frequently after discharge from the operating theatre than during induction of anaesthesia.

FACTORS POSSIBLY AFFECTING COMPLICATIONS

Previous studies have shown that several factors affect the incidence of respiratory complications. In a series of 16 065 patients, the poorer the preoperative physical status, the higher the incidence of respiratory complications occurring in the recovery room.¹² Similarly, the older the patient, the greater the incidence of respiratory complications.¹² Another study showed that the incidence of respiratory complications in the recovery room is increased in males and in elderly patients, and after thoracic or abdominal surgery.¹¹

In the present study, there were differences in the incidence of respiratory complications according to sex, presence or absence of preoperative airway problems, depth of anaesthesia at tracheal extubation, and weight (heavier or lighter than 90 kg) (table 6). The

reasons for these differences in the incidence of complications, particularly the difference between the sexes, are not clear from the present study. Other factors that we did not analyse — smoking habit, history of upper respiratory infection and obesity (in the present study, we only distinguished between patients heavier or lighter than 90 kg) could have contributed to the difference in the incidence of respiratory complications between males and females.

In addition, several other differences in anaesthesia management, such as the use or the avoidance of nitrous oxide during operation or oxygen supply after tracheal extubation, could also alter the incidence of respiratory complications. We could not analyse these factors because nitrous oxide was used in all patients and oxygen was always supplied after tracheal extubation.

TIMING OF TRACHEAL EXTUBATION

Tracheal extubation under deep anaesthesia has been recommended for patients undergoing intracranial or intraocular operation or for those in whom an increase in arterial pressure could be detrimental.^{8,9} This practice will reduce the incidence and degree of straining (bucking) or coughing and stimulation of on arterial or intraocular pressures. However, we have found that the incidence of other respiratory complications after tracheal extubation will be greater when the trachea is extubated while the patient is still deeply anaesthetized (table 6). This is true regardless of the type of operation (table 7), and still applies in the recovery room (table 5). Therefore, constant vigilance is required when the trachea is extubated while the patient is still deeply anaesthetized. Use of the laryngeal mask after tracheal extubation may be an alternative means by which to achieve "smooth extubation" and recovery.^{29,30}

This result is consistent with a previous study, which showed that the more conscious the patient is on arrival at the recovery room, the lower the incidence of respiratory complications.¹² However, two studies in children reported that the incidence of desaturation was greater when the trachea was extubated after patients had regained consciousness rather than when they were still deeply anaesthetized.^{31,32} In these studies there were no significant differences in the incidences of laryngospasm, coughing, breath-holding or airway obstruction,^{31,32} but this may have been because too few patients were compared (beta error) (70 or 100 patients in total).^{31,32} Future randomized, comparative studies of sufficient numbers of patients should clarify differences in the incidence of respiratory complications between these two modes of tracheal extubation.

MANAGEMENT OF POSTOPERATIVE RESPIRATORY COMPLICATIONS

During transfer of the patient from the operating theatre to the recovery room, and in the recovery room, there is a relative lack of monitors and equipment and anaesthetists are not always present. Once the patient has left the operating theatre, detection of complications may be delayed and prompt treatment may be more difficult. Several studies have shown that, during transfer from the operating theatre to the

recovery room, arterial haemoglobin oxygen saturation often decreases,³³⁻³⁷ even when oxygen is given.^{34,35} It is advisable to give appropriate oxygen therapy routinely and to use a pulse oximeter during the transfer of the patient and in the recovery room.

There are well established procedures for the management of airway problems during induction of anaesthesia,³⁸ but no comprehensive guidelines for dealing with airway problems after tracheal extubation. We believe that dissemination of a simple algorithm for effective management of airway problems, such as one for laryngospasm,³⁹ is urgently required. Proper training of anaesthetists and recovery nurses in the management of postoperative respiratory complications on the basis of guidelines is also required.

The anaesthetist is responsible for the care of the patient from induction of anaesthesia to full recovery.⁴⁰ Our results support the recommendation that an anaesthetist with sufficient experience should be present in the recovery room, at least during normal operating hours.⁴¹

In summary, we have shown that the incidence of respiratory complications associated with tracheal extubation can be higher than that during tracheal intubation.

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