Factors Influencing Choice Between Tracheostomy and Prolonged Translaryngeal Intubation in Acute Respiratory Failure: A Prospective Study

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One of the problems of prolonged ventilatory therapy in acute respiratory failure (ARF) is the need to choose between tracheostomy after 48 to 72 hours of translaryngeal (TL) tracheal intubation or the continuous use of the TL tube for a period of 10 days. Too often the choice has been based on retrospective studies or personal preference. To investigate this problem prospectively, 52 adults in ARF were divided sequentially into 2 groups on their 3rd day of TL intubation. Patients in group I (G-I) retained the TL tube for a total of 11 days; those in group II (G-II) were tracheostomized on the 3rd day. The following factors were used to evaluate the efficiency and complications in each group: patient's epidemiologic variables, daily pulmonary functions, severity of respiratory infections, and scores of post-intubation airway lesions.

No consistent statistically significant differences between the two procedures were seen in the pulmonary functions or the range of individual patient variables. However, with an early tracheostomy, there was an eightfold greater incidence of contamination of the airway by new organisms, airway lesions were more frequent and severe, and the need for the tracheal tube was extended.

To identify the epidemiologic variables and the pulmonary functions that discriminate between patients with serious airway lesions and those with mild lesions, and to evaluate the ability of these variables to differentiate the patients who died from those who survived, the distribution of all factors was compared in the two categories. The epidemiologic variables separated the patients according to their airway lesions only, while the difference in pulmonary functions was statistically significant only between the patients who died and those who survived.

DURING the past decade, there has been a dramatic change in the type of tracheal tubes used in the management of patients in acute respiratory failure (ARF).[1] In the early sixties, it was realized that an initial tracheostomy was justifiable only when translaryngeal (TL) intubation of the trachea was not possible.[2] It was then common practice to perform the tracheostomy within the following 24 hours, if the need for the tracheal tube continued.[3]

In the late sixties, interest increased in prolonging the period of TL intubation, because of dissatisfaction with the results of tracheostomy in some patients.[4] The complications of transtracheal (TT) intubation,

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Paper received: 2/21/75
Accepted for publication 7/29/75

fairly frequent and often serious,[5] included bleeding, difficulty in cannulation, dislodgement, generalized surgical emphysema, pneumothorax, tracheal stricture and fistulas, and scar formation. With improvements in construction of tracheal tubes and in the overall management of patients with an artificial airway,[6] clinicians prolonged the duration of TL endotracheal intubation.[7] This practice was also accompanied by complications, such as mucus obstruction, accidental extubation, pneumonia, ulceration of nostrils or nasal septum, hoarseness, cord avulsion-perforation, dislodgement of the tube into the right main bronchus, and tracheal stenosis.

Currently there is no agreement as to the optimum period of TL intubation after which tracheostomy is indicated. Even Lindholm, in an extensive study of prolonged tracheal intubation, affirmed that he could not establish a time limit.[8] Pontoppidan's group[1] retained TL tubes up to 8 days, while Safar[9] recommended tracheostomy on the 3rd day of TL intubation.

The present study was undertaken to compare the efficacy and safety of prolonged TL and TT intubation in adults in ARF and to identify factors that may influence the outcome of therapy.

METHODS AND MATERIALS

On their 3rd day of TL intubation, 52 adult patients in ARF who were judged to require continued intubation for a further period of time were sequentially divided into 2 groups. Patients in group I (G-I) were managed by continued TL airway for a total period of 10 to 11 days, after which tracheostomy was to be performed, if the need for an artificial airway continued. Patients in group II (G-II) were to be tracheostomized on the 3rd day of artificial airway care.* All 52 patients received the same respiratory, general, and supportive care, according to individual needs and the policies and procedures of the general intensive care unit.

Criteria for scoring respiratory infections included vital signs, laboratory findings, and x-rays (table 1). After extubation, patients were examined by a member of the ENT staff, using a Macintosh-blade laryngoscope and a fiberoptic bronchoscope. Pharyngeal, laryngeal, and tracheal lesions were rated according to modified Lindholm scoring system.[8] Epidemiologic variables and respiratory measurements (table 2) were collected daily on computer-coded forms by the second author, who was not in charge of patient care during the study.† Some of the data collected were deleted because of incomplete information, inadequacy of method of determination, or difficulty in statistical interpretation. The Fisher linear discriminant function test was used to quantitate the distribution of the epidemiologic variables in the following groups of patients: (a) patients who had prolonged TL intubation versus those who had an early tracheostomy; (b) patients who had mild airway lesions versus those who had serious lesions; and (c) patients who were extubated versus those who died.

TABLE 1
Score System for Quantification of Respiratory Infections

	Score	Maximum score
A. Clinical evidence		
1. Fever	1	
2. Pulse: 20% increase	1	
3. Respiratory rate: 20% increase	1	
4. Secretions	1	
5. Leukocytosis	1	
Total	5	5
B. Radiologic evidence		
1. Opacification, segment	1	
2. Opacification, one lobe	2	
3. Opacification, one lung	3	
Total	6	5
C. Laboratory evidence of pathogens in tracheal aspirate	5	5
Total	16	15

Student's *t*-test and analysis of variance were used to derive the significance of the differences between the mean values of repiratory measurements per day of management in the different groups. Statistical significance was obtained at the 0.05 level.

RESULTS

A. Prolonged Translaryngeal Intubation Versus Early Tracheostomy. — The linear

*Both TL and TT intubation employed portex low-pressure cuffed tubes.

†Coded forms available on request from Dr. El-Naggar.

TABLE 2
Epidemiologic and Respiratory Variables Recorded

1. Treatment { Prolonged TL / Early TT
2. Outcome { Extubated / Expired
3. Airway lesions { Mild (scores 0, 1, or 2) / Serious (scores 3)
4. Age, yr
5. Sex { Male / Female
6. Race { Black / Caucasian
7. Smoking { Yes / No
8. Alcohol intake { Yes / No
9. Narcotic habituation { Yes / No
10. Steroid medication { Yes / No
11. Indication for intubation
    a. $Paco_2 > 50$ torr
    b. $Pao_2 < 50$ torr
    c. Respiratory rate > 35 min
    d. Secretions
    e. Maintain a free airway
12. Mode of ventilation
    a. Assisted
    b. Controlled
    c. Assisted/controlled
13. Duration of tracheal intubation by
    a. TL tube
    b. TT tube
14. a. Internal diameter of TL tube (mm) 7, 8, and 9
    b. size of TT tube (French) 33, 36, 39
15. Number of attempts at TL intubation
16. Route of TL intubation { Nasal / Oral

Respiratory Measurements

1. Bacteriologic study of tracheal aspirate.
2. Score of airway lesions.
3. Score of respiratory infections (RI).
4. Alveolar-arterial O_2 tension difference with 100% inspired O_2 $P_{(A-a)}$ O_2 (100%)
5. Ratio of dead-space volume to tidal volume (V_D/V_T x 100)
6. Tidal volume (TV).
7. Forced vital capacity (FRC).
8. Effective dynamic compliance (EDC).

discriminant analysis test yielded an f $(16.35) = 1.31$; p value > 0.25. This indicated that the epidemiologic variables were equally distributed between the TL and TT groups. The type and frequency of organisms newly identified in daily examined tracheal aspirate was similar during the first 4 days of management G-I and G-II. However, between the 4th to 11th days, there was an 8-fold increase in the number of newly identified organisms in G-II in comparison to G-I (table 3).

The mean score for airway lesions/day of management (fig 1) was significantly higher in G-II than in G-I ($p<0.05$). The 26 patients in G-II had an average score of 1 for the lesions evaluated when these patients were tracheostomized on the 3rd day of TL intubation. This same score in G-I was observed on the 7th and 8th days. Because the patients in G-II were managed by two types of tubes, the average score on the 3rd day was added to that on subsequent days (fig 1). The combined scores of airway lesions in G-II were also significantly higher ($p<0.01$) than in G-I.

In a comparison of the percentages of the cumulative number of patients extubated or expired and the number of patients being treated in G-I or G-II at the specific day of management (fig 2), analysis of variance test showed the difference in these percentages between the expired patients in G-I and G-II were statistically insignificant,

TABLE 3
Frequency of Newly Identified Organisms in Aerobic Cultures of Tracheal Aspirate During Study Period

Type of organism	Group I	Group II
Hemophilus influenzae	2	4
Escherichia coli	5	6
Klebsiellae	2	10
Pseudomonas aerogenosis	4	9
Herella	1	1
Candida	1	0
Diplococcus pneumoniae	1	0
Proteus mirabilis	2	0
S aureus	0	4
Streptococcus	0	1
Total	18	35
Number of organisms 1st identified on 1st day	3	5
Number of organisms 1st identified during 1st 4 days	15	19
Number of organisms 1st identified during 3rd to 11th days	2	16

while the higher percentages in the extubated patients in G-I were statistically more significant than those in G-II. These results indicated a significant delay in extubating the tracheostomized patients (G-II), independent of the outcome or duration of therapy.

There were sporadic and inconsistent differences in the means and SD of the respiratory measurements according to day of management. In G-II, with the exception of V_D/V_T ratio determination, there was a significant deterioration in these measured values subsequent to the tracheostomy on the 4th day of management.

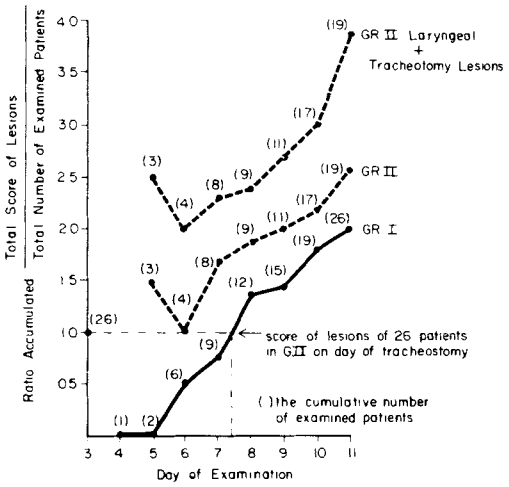

FIG 1. Cumulative scores of airway lesions: ratio of lesions in patients examined per day of examination.

B. Variables that Contribute to Airway Lesions.—Patients with lesions were divided into 2 groups: (A) Those with mild airway lesions (score 0, 1, or 2) and (B) patients with serious airway lesions (score 3 or over).

Linear discrimination analysis showed

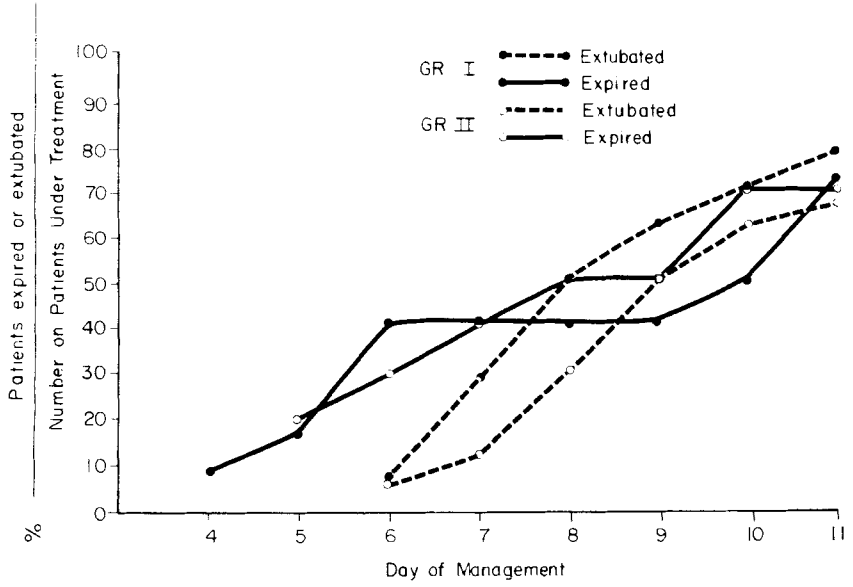

FIG 2. Percentage of expired or extubated patients of those being treated per day of management.

TABLE 4
Variables that Contribute to Airway Lesions (Descending Importance)

1. Use of transtracheal tube
2. Assisted ventilation
3. $Paco_2 > 50$ torr as indication for intubation
4. Duration of translaryngeal intubation
5. Race (Black more prone)
6. Secretions as an indication for tracheal intubation
7. TT tube 36 French
8. Duration of TT intubation
9. $Pao_2 < 50$ torr as indication for intubation
10. Use of steroids
11. Sex (females more prone)
12. TT tube 33 French
13. Smoking
14. TL tube size 8 mm ID
15. Patient extubated

Indecisive Variables Include

1. Initial diagnosis (medical or surgical)
2. Alcohol intake
3. Habituation to narcotics
4. Respiratory rate > 35 as indication for intubation
5. Free airway as indication for intubation
6. Duration of TT intubation
7. Number of attempts to intubate trachea translaryngeally

that 15 of 22 variables (table 4) correctly classified 46 patients out of 52 into group A and incorrectly classified 6 patients with mild lesions. The test yielded an $f = 4.33$, with 13 and 38 degrees of freedom, and a p value of <0.001.

There was no significant difference between the mean values of the 6 respiratory parameters (RI, $P_{(A-a)}\ O_2$ (100%), V_D/V_T, TV, FVC, or EDC) per day of management or the number or type of positive bacteriologic cultures in the patients who had mild or serious airway lesions.

There was no correlation between the airway lesions at the cuff site and the following factors: (a) duration of intubation; (b) type of tracheal tube; (c) extubation or death; and (d) epidemiologic variables or respiratory measurements.

C. Variables that Influence the Prognosis of Prolonged Tracheal Intubation (death during the study versus extubation).—The 52 patients included in the study were categorized as follows: (1) those who died during the study; (2) those successfully extubated and discharged from the General Intensive Care Unit (GICU). The linear discriminant function test, used to investigate the distribution of the epidemiologic variables between those two categories, yielded an $f\ (16.35) = 0.75$ with 16 and 35 degrees of freedom ($p<0.10$), indicating that the epidemiologic variables could not help predict which patients would die and which would be extubated.

Although there was no significant difference in respiratory measurements on the 1st day of management, in subsequent days significant and consistent differences were observed in the following measured values, in the following order: TV and FVC on the 2nd day, RI on the 3rd day and $P_{(A-a)}\ O_2$ (100%) and EDC on the 5th day. The mean values of the V_D/V_T x 100, however, showed no significant difference between the group of patients who died and the group subsequently extubated.

In the expired group, the percent incidence of identified organisms was double that in the extubated patient group, while the prevalence of *E coli, Pseudomonas* species, *Klebsiellae, Hemophilus influenzae,* and *S aureus* was almost 3 times greater.

Mean values of respiratory measurements in the extubated group and expired group on the 1st and last days of management are shown in table 5.

DISCUSSION

In the past, prolonged therapeutic tracheal intubation has been defined as the maintenance of an artificial airway for more than a few hours.[10] This definition is unsatisfactory, due to the common use of intubation in the management of ARF for longer periods.[1,3,9] We chose the period of 3 days to define prolonged intubation, because TL tubes are commonly used in the initial 48 to 72 hours of artificial airway care, while there is no agreement regarding the choice between TL and TT intubation beyond this period.

Advocates of TT intubation on the 3rd day of management claim better removal of secretions, reduction of dead space, and better tolerance by patients.[8] Advantages

TABLE 5
Means and Standard Deviations of Values on 1st Day of Management and Day of Extubation or Death

	Patients survived		Patients died	
	Means and (SD) on 1st day	Means and (SD) on day of extubation	Means and (SD) on 1st day	Means and (SD) on day of death
Number of observations	30		22	
Tidal volume (TV/ml)	269 (117)	409 (105)	213 (101)	188 (34.7)
Forced vital capacity (FVC/ml)	753 (358)	1227 (399)	42 (214)	728 (233)
Effective dynamic compl (EDC/ml/cm H_2O)	21 (6)	36 (8.5)	22 (7.4)	22 (8.8)
V_D/V_T ratio	49 (11.4)	38 (10.3)	50 (10.5)	49 (6.3)
$\triangle P_{(A-a)} O_2$ (100%)	397 (105)	244 (68)	391 (98)	423 (84)
Respiratory infections (RI)	4.3 (2.3)	2.16 (1.9)	4.9 (3)	9 (3.9)

1. There was no significant difference in the 2 groups between mean values on 1st day.
2. Differences between mean values on day of extubation or death in G-I and G-II were highly significant.
3. With exception of scores of respiratory infections, differences between mean values on 1st day and day of death were statistically insignificant. There was a highly significant difference between mean values on 1st day and day of extubation (p 0.005 to 0.001)

claimed for TL intubation for over 3 days include better tube stability and tracheal alignment, absence of a surgical wound, and less bacterial invasion.

In this prospective study, the differences in the daily respiratory measurements between prolonged TL intubation and an early tracheostomy were only sporadically significant. This indicated that the TL and TT tubes were equally efficient in the management of ARF. However, the disadvantages in an early tracheostomy include deterioration in post-tracheostomy pulmonary function measurements, which may not be well tolerated by the unstable patient, and an increase in identified pathogens, which may invite the unnecessary administration of antibiotics. There is also a tendency to delay removal of the TT tube, which increases the cost of patient care and prolongs the risks inherent in artificial airways. In addition, airway lesions (excluding those related to the cuff) in early tracheostomized patients not only showed significantly higher scores but also tended to be delayed and of a more serious nature.

One patient had a granuloma at the tracheostomy site at the time of extubation and was discharged from the hospital for outpatient followup. Two weeks later, he was seen in the emergency room, where he sustained cardiopulmonary arrest due to severe tracheal stenosis. Immediate resuscitation was successful; however, the patient did not regain consciousness and later died. Two more patients who had an early tracheostomy also developed tracheal stenosis; one had a resection anastomosis and the other a permanent tracheostomy. Another patient developed a tracheoesophageal fistula at the tip of the TT that was related to misalignment of the tube.

Two women with status epilepticus showed subglottic cicatrical web formation after 3 days of translaryngeal intubation. Both were successfully treated by dilation.

In our view, the major advantage of maintaining the TL tube for 11 days was the fact that only 10 out of 52 patients needed airway care beyond this period. Thus, 80% of the patients in ARF who required a tracheal tube for 3 days or more could have been spared the tracheostomy procedure.

The airway lesions described in this report were less severe or frequent than those reported by Lindholm[11] and by Hedden's group[12] but similar to those observed by Deane and Mills.[13] The latter investigators found fewer complications in patients intubated more than 100 hours. In our study, there was a linear correlation between the duration of intubation and the severity of the lesions observed. For this reason we recommend limiting the period of translaryngeal intubation to 11 days.

Factors common to patients with serious airway lesions (table 4) suggest that it is

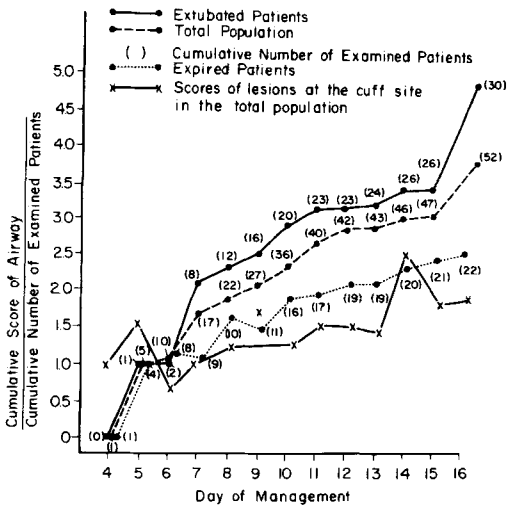

FIG 3. Cumulative scores for lesions per day of management in patients extubated, patients expired, total population of patients examined, and at cuff site.

the degree of friction between the artificial airway and the air passages that is significant. Lesions were more common (1) in patients on spontaneous or assisted ventilation, where friction is unavoidable; (2) in patients who survived (fig 3); and (3) in the 2 patients in status epilepticus. Unexpectedly, there was a correlation between steroid administration and serious airway lesions, but no correlation between these lesions and the number of attempts to intubate the trachea. The latter observation agrees with that by Fassolt.[14]

None of the epidemiologic variables or respiratory measurements (table 2) was useful for predicting the outcome of prolonged tracheal intubation for ARF on the 1st day of management, a favorable prognosis depending on improvement in pulmonary function. A poor prognosis was associated not only with lack of improvement in these measurements but also with an increased score in respiratory infections (table 5).

ACKNOWLEDGMENT

The authors wish to acknowledge with thanks the cooperation of the staff of the GICU, the Department of Surgery, and the ENT Division of Cook County Hospital.

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