A STUDY OF TRACHEOTOMY AT ST JUSTINE'S HOSPITAL, MONTREAL

H TURNIER, M D , K BERDNIKOFF, M D , AND Y CHAREST, M D

HAVING LONG BEEN IMPRESSED by the importance in paediatrics of serious broncho-pulmonary infections with grave and often fatal complications, we undertook a study of tracheotomy in these conditions. Without doubt, tracheotomy has acquired an important place in paediatric anaesthesia. By an evolution which has been slow but sure, tracheotomy has become well recognized as an essential part of the treatment of severe respiratory difficulties. The indications are well defined and the techniques used are based on the fundamental principles of respiratory physiology.²

This paper is a study of 52 cases of tracheotomy during the period 1958 to 1960.

Tracheotomy was found very effective and sometimes dramatic in its effects on children who were cyanosed or even at the stage of asphyxiation, with severe cyanosis and venous engorgement. Tracheotomy also occupies an important place in paediatric surgery because, with its more frequent use, it has led to a better appreciation of pulmonary haemodynamics.

Respiratory distress in children is such a dramatic condition, develops often so rapidly, and is fraught with such real danger, that we decided to review the subject, and to examine the case records of the 52 tracheotomies performed at our hospital in the years 1958 to 1960.

In going over the literature on respiratory distress one is immediately impressed by the vast range of material that is to be covered if one intends to be thorough. We very rapidly gave in to the temptation to delve into only one of the facets of the subject, i.e. the manner in which respiratory distress could be helped by tracheotomy.

Respiratory distress signifies respiratory insufficiency. This can occur at one of many levels. Narrowing Reardon's²⁰ classification and by order of frequency, these are (a) external pulmonary level, where uptake of O₂ and elimination of CO₂ take place, (b) between lungs and tissues, where transportation of CO₂ and O₂ takes place, (c) internal respiration, where O₂ and CO₂ are utilized by tissue cells.

It is fortunate that the second and third levels are found less frequently in paediatric practice, since less can be done as yet to correct any disorders arising from them. Amongst those that can be corrected are the anaemias, in which raising the haemoglobin level improves O₂ transport.

On the other hand many difficulties arise on the first level, that of the respiratory airway, where the O₂-CO₂ exchanges take place. These are far more obvious and are often more easily amenable to treatment. Many authors have given classifications both of the disorders of respiration and of the evaluation of them.

severity H Arey,⁴ for instance, breaks down the causes in the newborn infant to lesions of the central nervous system, pulmonary lesions, miscellaneous, such as congenital malformations of the heart, great vessels, paralysis of the phrenic nerve, diaphragmatic hernia, oesophageal atresia with fistula, and malformations of the lower jaw, epiglottis, or larynx. It will be seen from our tables that we would add posterior choanal atresia as a relatively frequent cause. An excellent evaluation of the respiratory function of the newborn is given by H Miller,¹⁶ who suggests counting the respiratory rate in the first 48 hours and who considers a rise above 60/minute as being a definite danger signal.

Apgar's index is also well known, though more complicated.³

Nelson, in his *Textbook of Paediatrics*,¹⁸ gives a classification of causes by chronological order (before, during, and after birth) in so far as the respiratory tract is concerned, and in anatomical order, from without inward, so to speak, and from above downward, starting with choanal atresia and ending with purely pulmonary lesions such as atelectasis and hyaline membranes.

De Sanctis and Varga⁸ have simply made a classification of the main states in which a respiratory emergency may arise, especially since respiratory difficulties may stem from a multitude of causes in one and the same child. Thus anything that tampers with the normal functioning of the central nervous system may produce (1) a change in the respiratory rhythm, which may go as far as complete arrest, (2) eventually a marked change in the acid-base equilibrium, and (3) a pooling of secretions in the trachea (thus causing a simple mechanical obstruction of the airway).

Thus respiratory distress through involvement of the CNS is due to at least three mechanisms and, when handling such a case, all three must be considered. This adds also to the difficulties plaguing anyone who tries to classify these cases, and brings us back to our study of the cases of tracheotomies in our hospital. In a purely arbitrary fashion three years were chosen (1958, 1959, and 1960, during which tracheotomies were performed on 52 children).

INDICATIONS FOR TRACHEOTOMY

Tracheotomy is now being used widely as a deliberate method of treatment rather than as an emergency procedure.¹⁴ With commoner recognition of the respiratory complications which may beset medical and surgical patients has come an increasing number of indications for the operation.^{6, 10, 11, 12} Tracheotomy has proved especially valuable in the prophylaxis and treatment of respiratory failure, particularly when this arises as a consequence of retention of secretions or in relation to an operation. The following is a tentative classification of conditions in which tracheotomy may be indicated.¹

- (a) Obstruction of the upper airway
 - Congenital anomalies
 - Trauma
 - Inflammation, acute and chronic
 - Neoplasms
 - Foreign bodies, paralysis
 - Extrinsic laryngeal diseases²

(b) Obstruction of the lower airway

Among the most common lesions of the lower airway are secretory obstruction and anomalies producing compression of the trachea and oesophagus particularly tracheal stenosis and foreign bodies

(c) Primary neuromuscular disturbances

Poliomyelitis

Tetanus

Botulism

Myasthenia gravis

Bulbar or peripheral neurological lesions

Severe debilitation and coma

(d) Mechanical interference with ventilation

Thoracic surgery

Multiple rib fractures

Persistent mediastinal emphysema

(e) Systemic diseases

Generalized infections

Poisoning and toxic states

Cerebrovascular accidents

Severe trauma with brain injuries

Neurosurgical procedures²¹

In general tracheotomy is indicated when in spite of good medical therapy respiratory obstruction progresses as evidenced by an increase in the respiratory

FIGURE 1 Appropriate set up for tracheotomy

FIGURE 2 Tracheotomy tube with cuff

rate in greater costal sternal and suprasternal indrawing and the increasing use of the accessory muscles when the heart rate continues to rise and remains above 160 when the child becomes restless and apprehensive and when there is diminishing air entry after a reasonable time of treatment Cyanosis and particularly grey cyanosis is a grave sign and suggests heart failure ¹⁰

DISCUSSION

It is a well known fact that mechanical problems dominate the picture in infant respiratory physiology The following points bear witness to this fact

- 1 There is a small respiratory exchange which is very variable from one minute to the next and respiration is always irregular in rhythm and amplitude
- 2 There is a small pulmonary capacity at this age
- 3 The larynx and major airways are of narrow calibre and this explains the

TABLE I
CONGENITAL MALFORMATIONS—FINDINGS

Sex	Age at tracheotomy	Clinical diagnosis	Anatomical	Bacteriological	Comments	Time elapsed till	
						Death	Decannulation
M	3 weeks	Multiple malformations	Laryngo malacia		Probable cause of death aspiration of food particles	3 months A	
M	<1 day	Posterior choanal atresia	Thick secretions in trachea and bronchi	Staphylococci (eye secretion)		17 days A	
F	2 months	Posterior choanal atresia			Reconstruction of posterior choanal orifice		4 months
F	2 days	Tuberous haemangioma	Lesion involving face, neck, mouth-trachea		Left hospital with endotracheal tube		>4 months
F	5 days	Pierre Marie Robin syndrome			Probable aspiration of food particles	28 days	
M	6 months	Laryngotracheo malacia	Massive bronchial suppuration			3 months	
M	2 months	Laryngo malacia and stenosis	Considerable inflammation, granuloma forms in larynx		Child left hospital with tube 2 years later		>2 years
F	1 month	Posterior choanal atresia		Staphylococci (eye secretion)			3 months
F	4 days	Posterior choanal atresia			Elective tracheotomy		6 months
F	6 weeks	Tracheo malacia	Myositis of larynx found on autopsy		Necrotic laryngotracheo-bronchitis developed	8 days A	
F	2½ months	Pierre Marie Robin syndrome	Considerable oedema and secretions			1 month A	
TOTAL 11 cases <1 day - 6 months							6 died 4 autopsied 5 survived

N B A = autopsy performed

TABLE II
RESPIRATORY TRACT INFECTIONS—FINDINGS

Sex	Age at tracheotomy	Clinical diagnosis	Anatomical	Bacteriological	Comments	Time elapsed till	
						Death	Decannulation
M	2 years	Acute laryngotracheobronchitis	Giant swelling, pus, and redness	<i>Pseudomonas</i> and streptococci			15 days
F	1½ years	Acute laryngotracheobronchitis	Swelling, redness	Not done			28 days
F	4 months	Acute laryngitis	Some secretions	Negative	Skull fracture a few weeks previously		27 days
F	3 years	Suppurating laryngotracheobronchitis	False membranes	Staphylococci			21 days
M	2 years	Pneumomediastinum and purulent bronchitis	Mucopurulent secretions	Staphylococci			7 days
M	7 weeks	Retropharyngeal abscess		Staphylococci	Operated preceding day for the abscess		10 days
M	2½ years	Acute laryngitis	Swelling + + + +, purulent subglottic plug	Staphylococci	There was subcutaneous emphysema preoperatively		8 days
M	2 years	Acute laryngotracheobronchitis	Swelling + + + +, redness + + + +	Streptococci	Hyperacute evolution		26 days
F	3 years	Septicaemia	Laryngeal and pulmonary oedema	<i>Haemophilus influenzae</i>	Hyperacute evolution	1 day A	
M	4 months	Acute laryngotracheobronchitis	Small glottis	Throat <i>Escherichia coli</i> and <i>Paracolon aerogenes</i>			41 days
F	3 years	Acute laryngotracheobronchitis	Swelling and redness, purulent secretions	Streptococci and staphylococci	Hyperacute evolution		11 days
M	2 months	Atelectasis, bronchopneumonia	Thick secretions, confluent bronchopneumonia	Staphylococci and <i>Candida albicans</i> and <i>Escherichia coli</i>	Case of cystic fibrosis of the pancreas	1 month A	
M	1 year	Acute laryngitis		Staphylococci	Decannulation difficult to achieve		1 month
M	4 years	Acute laryngotracheobronchitis	Giant swelling and redness	Streptococci	Dramatic relief from tracheotomy		11 days
M	18 months	Acute laryngitis	Swelling and redness	Staphylococci (throat)			10 days
TOTAL 15 cases		7 weeks - 4 years	15 cases acute laryngitis or laryngotracheobronchitis	9 staphylococci 4 streptococci		Only 2/15	

N B A = autopsy performed

TABLE III
POSTOPERATIVE COMPLICATIONS REQUIRING TRACHEOTOMY—FINDINGS

Sex	Age at tracheotomy	Type of surgery	Anatomical	Time elapsed between operation and tracheotomy	Comments	Time elapsed between tracheotomy and death	Decanulation
M	4 years	Removal of submaxillary gland	Nil	1 day			23 days
F	10 years	Closure of cleft palate	Mucous plug blocking trachea	21 hours	Hernia of cerebellar tonsils Giant cerebral oedema Remained unconscious after operation Cardiac arrest	2 days A	
M	1½ years	Laryngoscopy for cleft palate and laryngeal malformation	Fibrous band between vocal cords, coagulated blood in trachea	<1 hour	Cardiac arrest Remained unconscious, decerebrated, and convulsed Autopsy pulmonary and cerebral oedema	5 days A	
M	5 years	Fallot's tetralogy			Tracheotomy done prophylactically to facilitate use of Bird respirator		9 days
M	16 years	Correction of aortic stenosis		1 day	Pneumothorax and atelectasis lower left lobe, 18 hours after operation		7 days
F	11 years	Closure of atrial septal defect		3 days	Excellent evolution for 60 hours after operation when high fever and respiratory distress developed		9 days
M	7½ years	Closure of ventricular septal defect	Plug of pus in right bronchus, atelectasis upper right lobe	1 day	Remained unconscious after operation, convulsed Autopsy right lobe atelectasis, right bronchus full of pus, cerebral oedema	4 days A	
M	10 years	Lower left lobectomy for bronchiectasis	Thick jelly-like secretion left bronchus	8 hours	Streptococci Lancefield A grown from endobronchial secretion		10 days
M	15 years	Laminectomy for malformation of dorsal spine		6 hours	Remained unconscious after operation No autopsy	1½ days	
M	7½ years	Closure of atrial septal defect		1 day	Acute renal insufficiency, staphylococci, pericarditis, and bronchitis Unconscious	21 days A	
TOTAL 10 cases		1½–16 years		All but 1, within 24 hours		5/10 died	

N B A = autopsy performed

TABLE IV
RESPIRATORY DISTRESS OF CNS ORIGIN

Sex	Age at tracheotomy	Aetiology		Findings	Comments	Time elapsed till	
		Infections	Traumatic, mechanical			Death	Decanulation
M	8 years	Bulbospinal polio-encephalitis III		Respiratory paralysis and abundant secretions	Tracheotomy required 5 days after first symptoms appeared		11 days
M	3½ years	Bulbospinal polio-encephalitis III		Airway full of secretions	Cardiac arrest	5 days A	
F	6 years	Bulbospinal polio		Airway full of secretions	Died 7 days after first symptoms appeared	4 days A	
M	4 years		Skull fracture and loss of brain tissue	Considerable secretions			5½ months
F	15 years		Ruptured cerebral aneurysm	Mucous plug in lower trachea and bronchi	Remained a spastic hemiplegic		16 days
F	8 years	Bulbospinal polio III		Complete laryngeal paralysis	Swelling and thick mucous		8 days
M	11 years		Arnold-Chiari syndrome	Accumulation bronchial secretions	P E G performed a few hours before tracheotomy		1 month
M	2 years	Polio-encephalitis III		Paralysis vocal cords	Considerable immediate improvement after tracheotomy		22 days
F	3½ years	Bulbospinal polio I		Pus in trachea and right bronchus, acute pulmonary oedema	Fulminating evolution	2 days A	
M	8 years	Bulbar poliomyelitis I		Respiratory paralysis	Tracheotomy 4 days after first symptoms appeared		18 days
M	4 years		Skull fracture and loss of brain tissue	Thick bloody and mucous secretions			3 months
F	6 years	Acute pneumococcal meningitis		Trachea filled with viscous plug	Lung abscesses, thrombosis of right lateral sinus	1 day A	
M	3 years	T B meningitis		Trachea and bronchi filled with thick green pus	Died 3 weeks after first symptoms appeared	2 days A	
F	6 years	Bulbar polio-encephalitis I		Considerable secretions			7 days
M	8 years	Bulbospinal polio-encephalitis I		Paralysis and secretions			17 days
F	8 years	Bulbo polio-encephalitis			Intubation tried first with temporary relief		7 days
TOTAL 16 cases 2-15 years		10 polio 1 T B meningitis 1 pneumococcal meningitis	2 skull fractures			5/16 died 5 autopsied	

N B A = autopsy performed

importance in the child of inflammatory states and episodes involving spasm at this level, and also the gravity of laryngeal lesions

4 Any increase in dead space is proportionately more serious in children than in adults because of the weaker thoracic and abdominal musculature ²²

Tracheotomy not only permits us to overcome an obstruction which is high up but enables us to use a mechanical respirator more efficiently. It also stimulates the pulmonary circulation and improves the ventilation and permits better oxygenation and elimination of CO₂. The aspiration of bronchial secretions is also facilitated. By reducing the dead space, the pulmonary ventilation is greatly improved and pulmonary exchange is accomplished with less mechanical work ¹⁵

Tables I-IV show the principal categories into which our 52 cases fall and give an analysis of the anatomical and bacteriological findings along with some general comments

Tracheotomy is a measure of extreme urgency on which the whole method of treating respiratory obstructions is built. It is an operation of which the efficacy is universally recognized and whose frequency justifies a detailed study. In paediatrics a different attitude is required towards tracheotomy than in adults.

In adults, a small deviation from the normal respiratory pattern may be insignificant but, in a neonate or small child, the results of such a change can be disastrous

TRACHEOTOMY DURING RESPIRATORY INSUFFICIENCY

	Tidal volume (c c)	Volume of dead space (c c)	Tidal alveolar effective volume (c c)	Tidal alveolar effective volume (%)
Before tracheotomy	400	150	250	62
After tracheotomy	400	75	325	81
Before tracheotomy	300	150	150	50
After tracheotomy	300	75	225	75
Before tracheotomy	200	150	50	25
After tracheotomy	200	75	125	63

POSTOPERATIVE COMPLICATIONS

We have never been faced with a sudden death due to vasovagal reflexes or from sudden catastrophic haemorrhage

In our series we have picked out some cases of subcutaneous emphysema of the cervical tissues caused by a poor fit between the cannula and the tracheal opening. The consequences were never serious

The obstruction of the cannula by sticky secretions may occur gradually and unnoticed, and suddenly cause a severe obstruction. This we found to be a frequent problem and, when it happens, the clinical picture is always alarming because of the already narrow respiratory passages ¹

To avoid such a situation, it is necessary to have conscientious nursing with frequent observations of the colour of the face, lips, and extremities, and of the respiratory movements. Noisy respiration or tugging are premonitory signs of respiratory difficulties ⁷

DRY BULB TEMPERATURE °F

WET BULB TEMPERATURE °F		TEMPERATURE °F	
41	42	43	44
45	46	47	48
49	50	51	52
53	54	55	56
57	58	59	60
61	62	63	64
65	66	67	68
69	70	71	72
73	74	75	76
77	78	79	80
81	82	83	84
85	86	87	88
89	90	91	92
93	94	95	96
97	98	99	100

Printed by

Taylor Instrument Company

Rochester N Y

Printed by
Taylor Instrument Companies
Rochester N. Y.

DRY BULB TEMPERATURE °F

FIGURE 3

FIGURE 4 Humidifying gadget used in the recovery room. Tracheotomy mask shown in use with NCG No 24850 nebulizer and No 24681 corrugated tubing.

As can be seen from Table III 5 of the 10 cases had cardiac surgery performed for correction of septal defect aortic stenosis and Fallot's tetralogy. In one of these tracheotomy was done prophylactically. Two other children died of what seemed to be cerebral damage occurring at some time during the operation as did two others operated on for totally different reasons one who underwent a laryngoscopy for cleft palate and associated laryngeal malformations and one who underwent a laminectomy of the dorsal spine which was deformed never regained consciousness after their operations. All four of these children became decerebrate and some had convulsions and all died a few hours to 5 days after the operation. No clear cut cause for these deaths could be established. Two of them had had abrupt cardiac standstill but heart action was resumed almost immediately in both cases.

POSTOPERATIVE CARE

Close and constant care minimizes the complications considerably.

A calm and competent nurse who can give sympathy and self confidence to the patient is a great help. She must pay great attention to detail in keeping the airway always clear by the systematic application of suction. The tracheotomized patient has difficulty in expelling secretions.

Good co operation from the child is needed.

Because the air which enters the lungs does not pass through the nasal passages it is neither warmed nor filtered nor humidified by natural means. Therefore the room temperature should be about 72 -75 Fahrenheit and the relative humidity sufficient to prevent irritation of the respiratory mucosa (90%). At St Justine's we have high humidity rooms set up for this purpose.¹⁰

The child will need a substantial caloric intake which must be given in liquid form by a gavage tube until such time as the oesophageal oedema which follows a tracheotomy has disappeared. As the patient's general condition improves gradual additions can be made to this regimen until the normal diet is attained.

The facies, the character of the pulse and respiration and the temperature must be carefully watched.

The tracheal cannula must constantly be kept free of secretions owing to the complications which can result from a gradual accumulation in this site.

CONCLUSION

In summary tracheotomy is a simple technique although not without serious complications which renders invaluable service in many grave situations such as those of bronchial obstruction, tracheal compression, oedema of the larynx and paralysis of the respiratory muscles.

Clinicians should be alert to its efficacy and ready to apply this measure without hesitation in a situation that demands it.

FIGURE 5 Postoperative care in high humidity room

RÉSUMÉ

La détresse respiratoire chez les enfants constitue un drame, elle s'installe si rapidement et elle comporte un tel danger que la trachéotomie joue un rôle important dans son traitement. Un faible écart à la physiologie respiratoire normale peut être sans inconvénient chez l'adulte alors que, chez le nouveau-né ou le jeune enfant, cet écart peut être désastreux. Les auteurs ont étudié 52 cas de trachéotomie pratiquée chez les petits, à l'hôpital Sainte-Justine de Montréal, de 1958 à 1960. La trachéotomie s'est avérée efficace et quelquefois dramatique dans ses résultats chez des enfants cyanosés ou même en état d'asphyxie.

Dans la présente série, les complications de l'opération elle-même ont été minimales. Des sécrétions visqueuses peuvent obstruer la canule après l'opération, on évite cette complication par des soins attentifs et une surveillance de tous les instants. Une respiration bruyante ou saccadée est un signe prémoniteur de troubles respiratoires.

La trachéotomie est une opération simple et elle rend des services incalculables dans plusieurs complications graves telles que l'obstruction bronchique, la compression de la trachée, l'œdème du larynx et la paralysie des muscles respiratoires. Les cliniciens devraient être au courant de son efficacité, et ils devraient être prêts à l'utiliser sans hésitation lorsqu'elle est indiquée.

REFERENCES

- 1 MELICE, P. Indications and Complications of Tracheotomy in Acute Laryngitis in Children. *Acta Paediat Belg* 17: 5-17 (1963)
- 2 DUGAN, D. J. & SAMSON, P. C. Tracheostomy. Present Day Indications and Technics. *Am J Surg* 106: 290-306 (1963)
- 3 APGAR, V. Proposal for New Method of Evaluation of Newborn Infant. *Anesth & Analg* 32: 260-267 (1953)
- 4 AREY, H. M. & AREY, J. B. Respiratory Disorders of Newborn Infants. Correlation of Clinical and Pathological Observations. *Pediat Clin N Amer* 53-72 (Feb 1957)
- 5 ATKINS, J. P. Current Utilization of Tracheotomy as a Therapeutic Measure. A Review of the Literature and an Analysis of 526 Cases. *Laryngoscope* 70: 1672-1690 (1960)
- 6 CAWTHORNE, T., HEWLETT, A. B., & RANGER, D. Discussion. Tracheostomy Today. *Proc Roy Soc Med* 52: 403-409 (1959)
- 7 DAVIS, H. S., KRETCHMER, H. C., & BRYCE-SMITH, R. Advantages and Complications of Tracheotomy. *JAMA* 153: 1156 (1953)
- 8 DE SANCTIS, A. G. & VARGA, C. Handbook of Pediatric Medical Emergencies. St. Louis: C. V. Mosby (1951)
- 9 DIAMANT, H., KINNMAN, J., & OKMIAN, L. Decannulation Difficulties in Tracheotomized Children. *Acta Otolaryngol (Stockholm)*, Suppl 158: 39-42 (1960)
- 10 DUDLEY, H. A., BAKER, L. W., & ANDERSON, W. A. The Place of Bronchoscopy and Tracheostomy in General Surgical Patients. *J Roy Coll Surg Edinburgh* 7: 121-127 (1962)
- 11 HARRIS, L. H. & HOUSTON, J. Tracheotomy for Acute Respiratory Infections in Emphysema. *Lancet* ii: 1170-1172 (1961)
- 12 HEWLETT, A. B. & RANGER, D. Tracheostomy. *Postgrad Med J* 37: 18-21 (1961)
- 13 JACKSON, C. & JACKSON, C. L. Diseases and Injuries of the Larynx. New York: Macmillan (1942)
- 14 MATHESON, N. A. *et al*. The Management of a Tracheostomy. *Lancet* ii: 31-32 (1963)
- 15 LANDING, B. H. Anomalies of the Respiratory Tract. *Pediat Clin N Amer* 73-102 (Feb 1957)
- 16 MILLER, H. C. Clinical Evaluation of Respiratory Function in Newborn Infants. *Pediat Clin N Amer* 17-26 (Feb 1957)

- 17 ——— Studies of Respiratory Insufficiency in Newborn Infants *Pediatrics* 20 817-826 (1957)
- 18 NELSON, W E Textbook of Pediatrics, 7th ed Philadelphia and London N B Saunders (1959)
- 19 FEARON, B Acute Laryngo-tracheobronchitis in Infancy and Childhood *Pediat Clin N Amer* 9 1095-1112 (1962)
- 20 REARDON, H S Blood Chemical Deviations in Respiratory Disorders of the Immediate Postnatal Period *Pediat Clin N Amer* 3-16 (Feb 1957).
- 21 SKOLNIK, E M & FORNATOO, E J Tracheotomy Its Present Day Application *Laryngoscope* 68 32-47 (1958)
- 22 SMITH, C A The Physiology of the Newborn Infant, 3rd ed Springfield, Ill C C Thomas (1959)