ON THE USE
OF
FLEXIBLE TRACHEOTOMY TUBES.

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THE evils which frequently result from the use of silver or other rigid tracheotomy tubes are well known. Pain and irritation, accompanying and following the changing of the tubes, with troublesome bleeding from the granulating surfaces of the wound, are very common, the trouble, however, varying infinitely in different cases ; while ulceration of the trachea is often met with in post-mortem examinations. These evils are, of course, proportionately much more common in children than in adults, and with some forms of tracheotomy tubes than with others ; but they cannot be always avoided.

In a valuable paper on 'Tracheotomy in Children,'* Mr. Howard Marsh remarks, "Ulceration about the wound, or of the trachea around the cannula, is an event which, I believe, is much more common and more formidable than it is generally supposed to be. I have notes of

* 'St. Bartholomew's Hospital Reports,' 1867.

ten cases in which it took place. In four of these it was followed by a fatal hæmorrhage; in a fifth bleeding occurred, but was arrested with the actual cautery; in some of the remaining instances, in which the ulceration was situated at the upper extremity of the wound, coarse vascular granulations arose and obstructed the canal of the trachea, so as to hinder for a long time the removal of the cannula. The importance which the accident derives from its tendency to be fatal is increased by the probability that its occurrence depends almost entirely on the size and construction of the cannula that is employed. The majority of the cases referred to were under the care of those who were biassed by the impression that as large a tube as possible should be introduced, and in six of the cases a Fuller's tube was used throughout.

The ulceration was found, in those of the fatal cases of which I have notes, chiefly in one of two situations, either opposite the lower end of the cannula, or at its upper and posterior curvature." Among the cases, fatal from *various* causes, which are quoted by Mr. Marsh, was one in which the "thyroid cartilage was a good deal eroded;" in another, "around the wound the mucous membrane was found rather largely ulcerated," and "half an inch below the wound was another ulcer about as big as a pea." In another case, "for about three quarters of an inch below the wound of operation, the whole circumference of the trachea was observed to be covered with a dirty slough of the mucous membrane, which being removed, the cartilages beneath were left exposed."

Mr. Bryant remarks,* "The rigid tube, when required to be worn for long, too often excites ulceration by the pressure of its free end on the trachea, which may extend into the innominate artery."

Mr. Durham observes,† "Attention to the size, shape, and general construction of the cannula is of great importance." . . . "Sometimes the cannula is too short, and

* 'The Practice of Surgery,' 2nd edition, vol. ii, p. 31.

† 'System of Surgery,' edited by T. Holmes, 1870, vol. ii, p. 508.

the neck-plate becomes buried in the wound. Sometimes it is too long, and presses against the œsophagus behind, and projects in front to a greater or less extent from the wound, in which case it is very liable to be forced out. The cannulas in ordinary use are so curved that the lower extremity often impinges on the mucous membrane of the anterior wall of the trachea, and sometimes the convexity of the curve comes in contact with the posterior wall. In either case ulceration may be produced sooner or later, and very serious results may follow. Two cases have occurred in Guy's Hospital, in each of which ulceration so produced extended through the anterior wall of the trachea into the innominate artery. Fatal hæmorrhage, of course, ensued. Another instance of the same kind is recorded by Mr. Wood." . . . "Again, abscesses, bronchitis, pneumonia, pyæmia, and other more or less fatal conditions have sometimes resulted, directly or indirectly, from the inflammation or ulceration set up by the cannula."

Many attempts have been made to construct metal tracheotomy tubes in such a manner as to free them from the dangers attendant on their use, and with more or less success. The movable collar, as in French tubes, the ball-and-socket arrangement devised by Mr. Bryant, and, could the workmanship and material be perfect, the lobster-tailed cannula of Mr. Durham, are all improvements on the old-fashioned shapes, while the vulcanite tubes have been found, in many cases, to answer well. But the difficulty has been overcome only in part.

It had long occurred to me that an elastic tracheotomy tube might be constructed which would answer all the purposes of the rigid cannula, and at the same time be free from its disadvantages; but it was only last year that my idea was brought into working shape by my friend Mr. Paley, House-Surgeon to the Evelina Hospital, to whom I am indebted for taking much trouble in superintending the construction of an India-rubber tube, made by Mr. Millikin, of St. Thomas's Street.

This tube was made of ordinary India-rubber, and

answered the purpose for which it was intended very fairly ; but it was evident that a better material would be preferable, and the cannulæ have been since constructed of vulcanised red rubber, a material which is in a high degree elastic, tough, and durable, and remains almost unaltered after long soaking in pus or other like fluids.

The shape of the cannula is that of the ordinary silver tracheotomy-tube. There is no laryngeal opening, but this can be made at any moment, with a sharp knife or scissors, at the part of the tube which seems best for the case in which it is being used. The tube is single, and it has been found hitherto so easy of introduction and withdrawal, or, in other words, one tube can be so easily replaced by another that I have not thought it necessary to devise a combination of inner and outer tubes, as in the case of the silver cannulæ commonly in use. Indeed, the removal and replacement of the single flexible tube can be effected far more easily than a similar change of the innermost of the silver tubes, when two are employed, and with much less discomfort to the patient. Under some circumstances, however, a double tube would be very serviceable ; and I hope to have such a one constructed.

The elastic cannula can be easily introduced, as a rule, without any help in the shape of "guide" or forceps ; but, occasionally, it is found more convenient to employ one or the other. A pair of dressing-forceps has been found to answer well, the tube being compressed near its end ; or forceps may be used like those shown to the Society, which are also of suitable shape for acting, if required, as a trachea-dilator. An elastic catheter, introduced through the tube, so as to act as a guide, has been also found sometimes of service.

Hitherto the elastic cannula has been inserted at periods varying from one or two days to as many weeks after the operation, a silver tube having been previously in use ; but I am disposed to urge that the single tube should not be used earlier than three or four days after operation, not because there would be any risk of contraction and

consequent interference with the patency of the cannula at an early period (for I believe there is no danger of this if the tube be properly constructed), but on account of the disadvantages attendant on the use of all single tubes, while the trachea is still freely movable beneath the soft parts ; in other words, when the collapse of the cut edges of the wound, together with a very little want of due relation between them and the incision in the soft parts, may render the reintroduction, especially of a flexible tube, difficult. With a *double* elastic tube this period may, probably, be shortened with advantage, but experience is wanting with respect to it.

The first question which will naturally occur to all is, whether the elastic cannula is capable of withstanding the nipping action of the margins of the recent wound in the trachea, and of those of the wound in the soft parts also, at a subsequent period, when only a fistulous track remains. The answer may, I believe, be given most positively that there is no danger from this cause, and that the tubes may be worn for months without a mark on them to show where they have been gripped ; and this, notwithstanding the strong tendency to contraction on the part of the wound. In two cases which have come under my notice, it was impossible, after the removal of the elastic cannula for a few hours, to reintroduce it, and a silver one could be substituted only by using some little force ; indeed, in one case, several minutes elapsed before the house-surgeon could complete the introduction of a silver tube. But both before and after this, there was not the slightest difficulty in the introduction of the flexible tubes, when they were being used almost continuously, nor the slightest evidence of obstruction on account of pressure by the edges of the wound.

One well-known disadvantage of rigid tracheotomy tubes lies in the difficulty of knowing beforehand exactly the shape and size which are suitable for any given case, a very slight difference in these respects making a very great difference in the comfort, and sometimes, when the

tube is long worn, in the safety of the patient. This objection is quite removed by the use of flexible tubes, which accommodate themselves readily to different cases. At the same time, if rather too long, they can be shortened with a knife or scissors, according to the requirements of the individual case. Moreover, when two cannulæ are used alternately, one may be made rather shorter than the other; and thus, the point of pressure, so far as the extremity of the tube is concerned, is changed every few hours, an object of some worth, probably, even with flexible tubes, although not to the same extent as in the case of rigid ones.

The advantage of flexible tubes in cases in which, on account of some slight deviation from the middle line of the wound, either in the trachea or soft parts, a rigid tube will not "sit" well, is obvious.

It is, perhaps, scarcely necessary to refer to the greater safety of elastic tubes, when their removal and reintroduction are entrusted to nurses or others not accustomed to surgical manipulation. Practical experience, as will be seen from the appended notes of cases, has shown, too, that there is rarely any corresponding disadvantage with respect to greater difficulty of introduction. It may be well, however, to remind those who may use the flexible tubes, that it is absolutely necessary, during their employment, to have always near at hand either a bivalve silver tube, or, much better, a simple trachea-dilator, of which the kind shown to the Society is perhaps the best, so as to be prepared for any emergency. I have a record at present of four cases in which a flexible tube could not be introduced. In one, the attempt was made at too early a period after the operation, and the silver cannula was therefore replaced. In two others, the difficulty occurred during the period of convalescence, when the elastic tube had been left out for a few hours. After the substitution for a short time of a silver for the elastic tube no further difficulty occurred, and the use of the latter was resumed. With a proper guide or dilator, even in these cases,

probably, the flexible tube might have been reintroduced; but until further experience has been gained, it will be best to have a bivalve silver tube at hand for an emergency. The circumstances of the fourth case, unfortunately fatal, were peculiar, and will be best shown by the appended note from Mr. Clutton. It is not clear that in this case the blame is fairly chargeable at all to the flexible cannula, but if it be so, the case only forms an additional warning of the necessity of having a dilator always at hand.

The elastic tubes are very durable. In one case two of them, used alternately, lasted for six months, and would have lasted longer had they been required. If they have been laid by, however, for a time, they should be roughly handled before use, in order to test their strength and pliability, and no tube should be employed if, with the strongest pressure, there is the slightest tendency on the part of its walls to stick together—an event which can only happen with inferior kinds of red rubber. I have seen it occur only once.

Under certain special circumstances elastic tubing of different kinds has been occasionally employed as a substitute for the ordinary rigid cannula, but, so far as I can discover, India-rubber tracheotomy tubes have never been made hitherto for systematic use. The idea, however, is so obvious, that I cannot doubt it has struck many besides myself, and that the way has been so far prepared for their adoption.

The following are brief notes of some cases in which flexible tracheotomy tubes have been used. I am indebted for the details to Mr. Paley, house-surgeon, and Mr. Andrews, registrar, at the Evelina Hospital, to Mr. Edwards, late house-surgeon at St. Bartholomew's Hospital, and to Mr. H. H. Clutton, resident assistant-surgeon to St. Thomas's Hospital.

I am informed also by Mr. Mason, house-surgeon to the Children's Hospital; Great Ormond Street, that the flexible tubes have been found there to answer well the purpose for which they were constructed.

CASE 1.*—This, the first case in which the flexible tube was employed, was that of a little girl two years old, who was admitted into the Evelina Hospital, October 5th, 1875, under the care of Dr. Frederick Taylor. There was evidence of considerable laryngeal obstruction. No diphtheritic membrane could be seen, and the urine contained no albumen. The symptoms not abating under the use of the steam-tent and other measures, tracheotomy was performed by the house-surgeon, Mr. Paley, on the evening of the day of admission into the hospital.

The case did well, and at the end of a fortnight a flexible tube of ordinary India rubber was substituted for the silver one, and was changed every two days. It was introduced with less pain, was more comfortable, and caused less irritation than the metal tube. The tube was worn for a month, during ten days of which the child was running about the ward. At the end of this time its use was discontinued, and soon afterwards the patient left the hospital well.

CASE 2.—A boy, $3\frac{1}{2}$ years old, was admitted into the Evelina Hospital, under the care of Dr. Baxter, September 5th, 1876, with symptoms of croup. Four days afterwards there was great dyspnoea, and tracheotomy was performed, in the absence of the house-surgeon, by the registrar, Mr. Andrews. On the fifth day after the operation a vulcanised red-rubber tube was substituted for the silver. It could be removed and reinserted with much less difficulty and discomfort to the patient than the innermost of the two silver tubes which had been previously employed, and it seemed to excite less exudation from the operation-wound, and was easily kept clean. The changing of one elastic tube for another could be managed, it was found, with almost complete absence of discomfort to the patient.

On the ninth day after the operation the tube was removed for two hours, and then easily reinserted. On the following day it was again removed, and there being

* Published in the 'Lancet,' December, 1875, by Mr. W. E. Paley.

no recurrence of dyspnœa, the wound was allowed to heal, and soon afterwards the patient left the hospital well.

CASE 3.—A girl, $2\frac{3}{4}$ years old, was admitted into the Evelina Hospital, under the care of Dr. Baxter, September 24th, 1876. She had suffered from sore throat and difficulty of breathing, it was said, for a week. At the time of admission there was marked laryngeal cough, but not much interference with respiration. The fauces were injected, and the tonsils covered with greyish, doubtfully membranous exudation. The breath was offensive.

September 28th.—The child seemed better, but there was a patch of exudation on the uvula. On the evening of this day the breathing became laboured, and with only a temporary improvement on the 29th. Dyspnœa became urgent on the 30th, and tracheotomy was performed by the house-surgeon, Mr. Paley.

October 3rd (third day after operation).—The silver tube was replaced by an elastic one without any difficulty. The latter was not changed for twenty-four hours, and at the end of this time it seemed less foul than is commonly the case with the metal tube at the end of a much shorter period.

During the following week the use of the elastic cannula was continued, and on the tenth day after the operation, the patient having done well, it was left out for six hours. Some dyspnœa, however, then occurred, and an unsuccessful attempt having been made to reintroduce the flexible tube, a silver one was with much difficulty substituted. Two days after this the silver cannula was again replaced by the elastic tube, which was worn at intervals for five days more, when it was discontinued, and no further difficulty of breathing occurring, the child was discharged well October 28th. The ease with which, excepting the occasion referred to, the elastic cannula could be introduced in this case was very marked. It was changed every morning by the sister-in-charge.

CASE 4.—A boy, 4½ years old, was admitted into St. Bartholomew's Hospital, under the care of Dr. Black, February 22nd, 1876, with symptoms of croup. On the following day tracheotomy was performed by the house-surgeon in charge, Mr. Edwards.

February 27th (fourth day after the operation).—An India-rubber tube was substituted for the silver, and changed once every twelve hours. It was found to be less irritating than the silver tube, and did not become clogged so readily. It could also be withdrawn and reintroduced with much more ease than the innermost of the two tubes previously employed.

March 1st (eighth day after operation).—The tube was taken out to-day for about half an hour, but at the end of this time the child began rather suddenly to suffer from dyspnoea, and the wound had so far contracted as to render the reintroduction of the tube difficult. It was managed, however, after a little trouble, by the sister of the ward.

3rd.—The elastic tube was left for sixteen hours without changing. On the following day a laryngeal hole was made in the tube. Up to this date the flexible tube had been occasionally changed for a silver one, but after March 9th two flexible tubes were employed alternately.

15th.—The child can articulate well when the outer opening of the tube is closed by the finger.

From this time onwards the patient did well, but all attempts to dispense with the use of the tube proved unsuccessful. On one occasion, when it had been left out for an hour or two, it was found impossible to reintroduce it, and a silver cannula was, with some little force, substituted. The use of the flexible tubes was, however, resumed a few hours afterwards.

At the beginning of August (five months after the operation) the child was sent to Brighton, and Mr. Langdale, house-surgeon to the Sussex County Hospital, informs me that the elastic tube continued to be worn, and was changed once daily. Several attempts were made, Mr. Langdale adds, "to accustom the boy to do without the

tube, but he suffered from too much spasm of the glottis, until on one warmer day than usual the tube was left out for half an hour, and the length of time was increased every day until the wound became so contracted that the tube could not be replaced at all, and eight weeks after admission (seven months after the operation) the wound closed altogether. The vocal cords seemed perfect, the boy's general health improved, and he left the hospital well."

CASE 5.—A little girl, 5 years old, was admitted into St. Bartholomew's Hospital, under the care of Dr. Black, June 30th, 1876, suffering from croup. On the same day tracheotomy was performed by Mr. Edwards, house-surgeon, and a silver bivalve cannula was introduced. Temperature 103·8°; pulse 150; respiration 32. In the course of the following day the breathing continued difficult and hurried, and there seemed to be a considerable quantity of mucus, which the child had no power to expel.

July 2nd (second day after operation).—In the course of the morning it was necessary to remove the cannula three times, and on each occasion Mr. Edwards, with polypus-forceps, drew out through the wound several pieces of false membrane. On the same day (thirty-six hours after the operation) an India-rubber tube was substituted for the silver, with marked improvement in the breathing. On the night of July 2nd the breathing became much worse suddenly, and the patient died fifty-four hours after the operation. At the post-mortem examination a piece of false membrane was found stretched across the bifurcation of the trachea.

I am indebted to Mr. H. H. Clutton, resident assistant-surgeon to St. Thomas's Hospital, for the following account of two cases in which the elastic tube has been employed.

"St. Thomas's Hospital; November 26, 1876."

"We have had two cases of tracheotomy in the adult since August, in which the elastic tube was used.

“The first case, a man about 30 years of age, wore a silver bivalve for about a month. It was then changed for the India-rubber tube, as it seemed evident that he would have to wear one for some considerable length of time. The man has uninterruptedly worn this elastic tube for now over two months, taking it out and introducing it himself, with the help of a looking-glass, as easily as he could the silver one. He is now an out-patient, still wearing the tube. He finds it much more comfortable, and would on no account change it for a silver one, as it readily allows him to turn his head in any direction without pain. With cleanliness, too, it keeps perfectly sweet.

“The second was a case of syphilitic laryngitis in a woman about 23 years of age. The elastic tube was introduced about a fortnight after the operation, with very great relief to the patient. No guide, such as a pilot, dilator or forceps, was necessary for its introduction. The lips of the external incision had a tendency to close the wound by the drawing in of the sides during inspiration; but as soon as they were separated by the finger and thumb, one on each side of the wound, the opening in the trachea, which had by that time become firmly adherent to the soft parts, was seen to be patent and fixed, so that the elastic tube could with ease be introduced, contrasting strongly with the condition which is seen for forty-eight hours at least after the operation, in which the trachea is jerked up and down, and requires something stiff and probe-pointed for the easy introduction of a tube.

“The elastic tube was in this case, as in the first, a great comfort to the patient. She could turn and move her head without fear or pain, and the irritating cough which she had had with the former tube was much lessened on the introduction of the elastic one.

A sad sequel occurred to this otherwise successful case. The house-surgeon and myself were suddenly called on Sunday afternoon and found her dead, with the tube lying on the locker. The nurse's account was that she was seized with a fit of coughing, and was seen to throw the tube upon

the table (for she was walking about the ward), and then to become suddenly asphyxiated. I thought at first that the tube had been dragged out by being forcibly bent upon itself, but this was evidently not the case, for the tube was found on the table with the tape attached, so that she must have deliberately untied it. The *possibility* of the elastic tube, although firmly tied in, being capable of removal without untying the tape should be borne in mind, although we have no proof that it would be a likely accident. In this case no blame can be attached to the elastic tube, for it was evidently deliberately untied.

"As regards replacing the tube I think that possibly if the nurse had had a silver tube by the patient's side she might have introduced it. But it so happened, most unfortunately, that, although there were two nurses and the sister, who were attached to the ward and had introduced the elastic tube for about six weeks, none of them were in the ward at the time of the accident; the patient was walking about the ward and considered quite safe, except at the time of changing the tube, and she had never before attempted to remove the tube herself. The nurse who was in charge of the ward was unaccustomed to the elastic tube and failed to introduce it; it is possible that if she had had a silver one she might have succeeded, but I am quite certain that if one of the nurses who were accustomed to change her elastic tube had been there they would have found no difficulty in reintroducing it. It could be introduced by itself with forceps or with an ordinary pilot.

"In conclusion, I may say that a patient who has once worn the elastic tube would not, I should think, readily allow it to be replaced by the silver one, and that although we have met with this sad accident, I cannot see that the blame ought in any way to be attached to the tube."

Postscript.—Since this paper was read a case has occurred in which an India-rubber tracheotomy tube, having become brittle, was broken by a patient while in use, and a part

fell into the trachea. The patient was admitted into Guy's Hospital, under the care of Mr. Howse, and the tube was subsequently extracted. The fact indicates the necessity, insisted upon in this paper, of examining the tubes carefully from time to time, and discarding them if they have lost their due elasticity. To prevent, as far as possible, any such occurrence in future, the tubes are now constructed, in accordance with a suggestion kindly made by Mr. Donald Napier, with the addition of a canvas lining between the layers of rubber.