

ASPECTS OF TREATMENT*

OESOPHAGEAL STRICTURES

TREATMENT BY SLOW CONTINUOUS DILATATION

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Summary

A NEW METHOD of slow dilatation of oesophageal stricture is presented, using a sprung tube which exerts a gentle radial pressure over an extended period. This offers room to swallow a soft to light diet during treatment, while resulting in wide dilatation with normal swallowing immediately after withdrawal. The results of treatment in terms of diet and remission of strictures are compared with those obtained by routine bouginage in the 9 cases presented. In addition, the benefit in 50 cases of malignant stricture is referred to.

SLOW DISTORTION AND stretching of tissues is practised in various branches of surgery, but has hardly been applied to hollow organs. Protruding teeth in the growing child can be moved back into normal position by the constant pressure of tensile steel wires. The scars overlying joints can be stretched to some extent by constant gentle physiotherapy or slow-stretch apparatus. Cosmetically, the principle of slow dilatation is used by certain native tribes who, over a period of months or years, may dilate holes made in the lobes of the ears by inserting ornamental discs of progressively increasing sizes, resulting in a gross degree of dilatation.

Principles of dilatation

Slow dilatation can be applied to a strictured oesophagus by employing an elastic tube which will exert a constant pressure over a long period. The pressure, however, must be controlled; if it is too great, necrosis of tissues ensues, while if it is too little, no dilatation occurs. Between these two undesirable results must lie a therapeutically useful range of pressures, where gentle atraumatic dilatation can be effected. This being so, it would be reasonable to assume that the result might be more long-lasting than that obtained by routine bouginage, a forceful method of stretching which initiates the vicious cycle of trauma, inflammation, healing by granulation tissue, scarring, and further restructuring in weeks or months. Furthermore, as stressed by Harrison¹, there are the inherent risks of perforation and those attendant upon repeated anaesthetics.

*Fellows interested in submitting papers for consideration with a view to publication in this series should first write to the Editor.

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The degree of dilatation obtainable by bouginage is determined by the size of bougie that can be passed down the oesophagoscope. This limitation is not present when an elastic tube is used, dilatation to any required size then being possible.

Construction of the dilator

The dilator is a tubular structure consisting of a high-tensile stainless steel wire cylindrical braid, having the property that when compressed it elongates and when released it returns to its former resting diameter. The braid is covered by a protective non-reactive rubber sheath and the ends of the wire are individually twisted, bent, and treated to eliminate sharp edges. It is also contoured (Fig. 1) to ensure

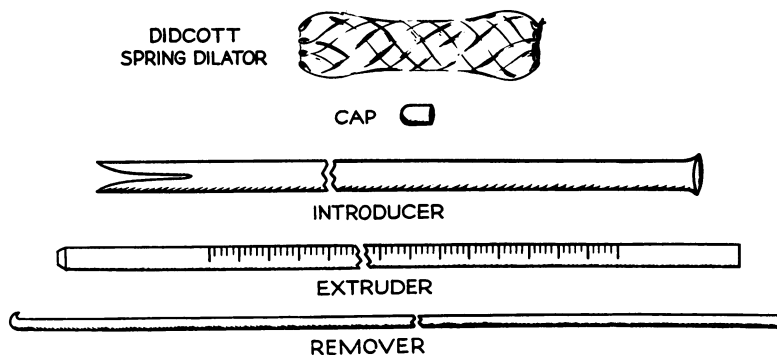


Fig. 1. Diagram of apparatus.

smoothness, and bulbous ends prevent the tube slipping through the stricture either way. Nylon purse-string loops are woven into the mouth of the dilator to facilitate removal.

Method of insertion

Instruments needed are as follows (see Fig. 1):

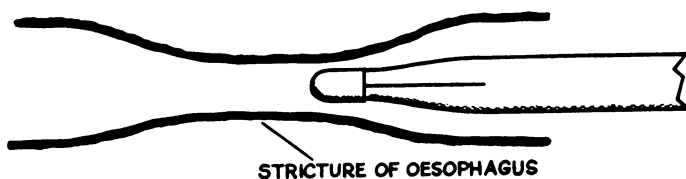
1. Teflon introducing tube.
2. Rubber caps for streamlining the end of the introducing tube (or obturator with cap to round off the end of introducing tube, not shown).
3. Extruder rod with metric graduations.
4. Wire rod with hook.

After preliminary bouginage the introducing tube, which is made of smooth, thin-walled plastic such as Teflon, is passed through the stricture, with rubber cap fitted, via an oesophagoscope (Fig. 2). The stricture having been negotiated, the cap is dislodged into the distal oesophagus with a rod passed down the introducing tube. The cap is too small to cause intestinal obstruction. Alternatively, a special small elastic cap

can be used in the same way except that it is attached to a wire rod. Thus it can be withdrawn through the introducing tube after release.

The dilator is well smeared with lubricating jelly, manually compressed, and pushed into the proximal end of the introducer tube (Fig. 3a). The extruder ramrod, which fits into the introducer tube, is used to push the dilator down to the desired level in the oesophagus so that it sits precisely within the stricture (Fig. 3b). The exact site can be checked with reference to the incisor teeth and the graduations on the ramrod,

INTRODUCTION OF DILATOR



REMOVAL OF CAP FROM INTRODUCER

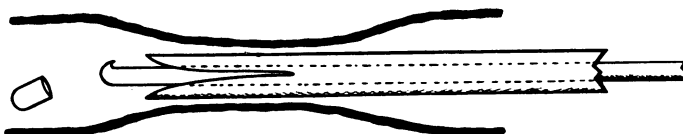


Fig. 2. After bouginage, the introducing tube with cap fitted is passed via oesophagoscopy through the stricture, and the cap is then dislodged.

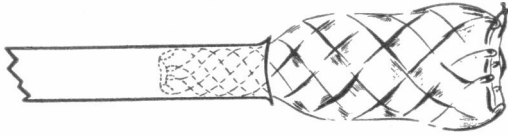
so that the upper end of the dilator is just above the stricture by about 2 cm, and the waist of the dilator lies within the stricture with the bulbous ends in normal oesophagus. A mark on the patient's chest in indelible ink to indicate the level and length of the stricture can be helpful both for introduction and subsequent radiotherapy in malignant cases.

Once the correct position has been established, the introducing tube is withdrawn while the ramrod is held steady to maintain the dilator in position (Fig. 4a). The dilator is thus extruded and left in situ in the compressed state (Fig. 4b), and is thereafter free to expand, exerting gradual pressure over a long period to achieve considerable dilatation, the bulbous ends keeping it stable. The position should be checked by oesophagoscopy and if further adjustment is required, the dilator can be moved using long 'crocodile' forceps.

To aid stability further if the dilator is left for long in situ, and to give warning of displacement, a thread can be tied to the dilator purse-

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LOADING OF DILATOR



PASSAGE OF DILATOR

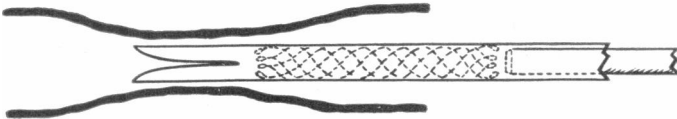


Fig. 3. (a) The dilator having been very well lubricated is manually compressed and pushed into the introducing tube. (b) The extruder ramrod is used to push the dilator down to the correct level within the stricture.

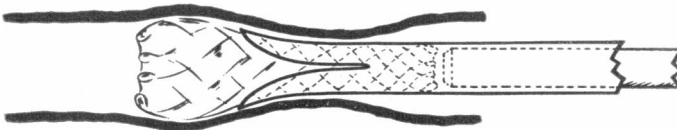
string before insertion. The proximal end is brought through the nasopharynx and tied to a small monofilament nylon eyelet stitched to the side of the nostril.

Tight or irregular strictures

When introduction via oesophagoscopy is impossible owing to a tight or irregular stricture, it may be effected by means of a gastrostomy as follows:

1. If only a small bougie can be passed into the stomach, the end

INSERTING DILATOR INTO STRICTURE SITE



DILATOR IN SITU



Fig. 4. (a) With the extruder ramrod held steady, the introducing tube is withdrawn, leaving the dilator through the stricture. (b) The dilator extruded in the correct position with its waist in the stricture.

can be brought out through the gastrostomy using a bronchoscope or small sigmoidoscope, and dilatation is then carried out by the 'railroad' method. Before removal of the last bougie the introducing tube is tied over its end, railroaded through, and the dilator introduced in the normal way.

2. If a bougie cannot be passed down from above it can often be passed up from below, again using a bronchoscope or small sigmoidoscope through the gastrostomy or at laparotomy, and then the above method (1) is carried out.

3. Sometimes no bougie can be passed owing to a ledge or other irregularity, while barium swallow still shows passage of contrast. Here the old method of swallowing a small lead shot attached to a cotton thread is worth a trial. If X-rays indicate its passage to the stomach it can be picked up via the gastrostomy and the railroad is established; introduction is then carried out as above.

Removal of dilator

A nylon purse-string suture is incorporated into the upper end of the dilator (Fig. 5). The operator uses the wire rod with hook (Fig. 1) to pick up a loop of purse-string and pull on it while the dilator is held



Fig. 5. Removal of dilator.

steadily, the end of the oesophagoscope being used for counter-traction. This causes the upper end of the dilator to contract, after which the entire apparatus can be easily and atraumatically removed from the oesophagus.

Selection of dilator

Various sizes are obtainable, with resilience varying from soft to firm. The length of dilator used depends on the length of stricture, as the bulbous portion must be situated in normal oesophagus.

A soft, thin-walled dilator is normally used, being the least likely to damage the oesophageal tissues. For very hard fibrous strictures and occasionally carcinoma, however, a firmer tube may be required initially, but after full dilatation it can be exchanged for a soft tube for comfort. Benign strictures generally require a soft tube, and though the dilatation may take longer, the action is more gentle. During the process anteroposterior and lateral penetrating X-rays are taken at 6 ft. (1.8 m) to indicate the extent of dilatation which ensues over a period

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of a week or more. When full dilatation has occurred the dilator is best left in situ for another 2 or 3 weeks or longer, to allow the tissues to stabilize and epithelialization to occur around the tube.

Some degree of inflammation, due to the presence of a foreign body, is inevitable, but this gradually settles after the dilator is removed. Although some initial narrowing occurs, a good lumen remains for a much longer period than is common after routine bouginage, particularly when wide dilatation has been achieved.

Results (non-malignant cases)

The results in the 9 cases of non-malignant stricture so far treated have been encouraging, considering the fact that these include those in which the technique was still in the early stages of development. In every case, after completion of treatment, the patient has been able to swallow a full normal diet, and the period of remission has been longer than that obtained from bouginage (see Fig. 6). The diameters of the various dilators which were employed and the time they were left in situ before each remission are shown in the table.

The stricture was caustic in Cases 1, 2, 4, 8, and 9 and anastomotic in Cases 3 and 6; it followed Heller's operation in Case 7 and the cause was undetermined (?tuberculosis) in Case 5.

Case summaries (Chronological order)

Case 1 (L.M.) This patient, a woman of 28 years, had swallowed caustic soda 12 months before and developed such a tight 5-cm stricture that she was requiring bouginage over a 14-week recorded period at 1- to 2-weekly intervals, which enabled her to swallow only a liquid or soft diet.

A series of graduated sizes of dilator was used, starting from 15 mm in diameter and ending with a 25-mm dilator, and in each case her remission period was much longer than before. These gave remission periods in the region of 7-8 months when left in the oesophagus for 2-4 weeks, and finally the last remission was 15 months. She was a patient with poor teeth and thus her ability to chew her food very fine was limited, but she managed to take a light diet when a 20- or 25-mm dilator was in her oesophagus and a completely normal diet after the completion of every dilatation. She was the first patient to be treated, and removal of her tube proved difficult in the early stages; a special oesophagoscope with an expanding end had to be developed and used for this purpose. A little excoriation was caused, yet in spite of this her result was still far better than with bouginage. Subsequently the purse-string loop was incorporated in the upper end of the dilator and this eliminated the problems associated with removal.

Some excoriation of the oesophagus with superficial ulceration of the epithelium was evident after removal of the dilator on every occasion, but the oesophagus was so wide that a large-size oesophagoscope could be passed through the stricture into the stomach with ease and, when looked at 2 weeks after removal of the dilator, it was found that the ulceration had virtually healed.

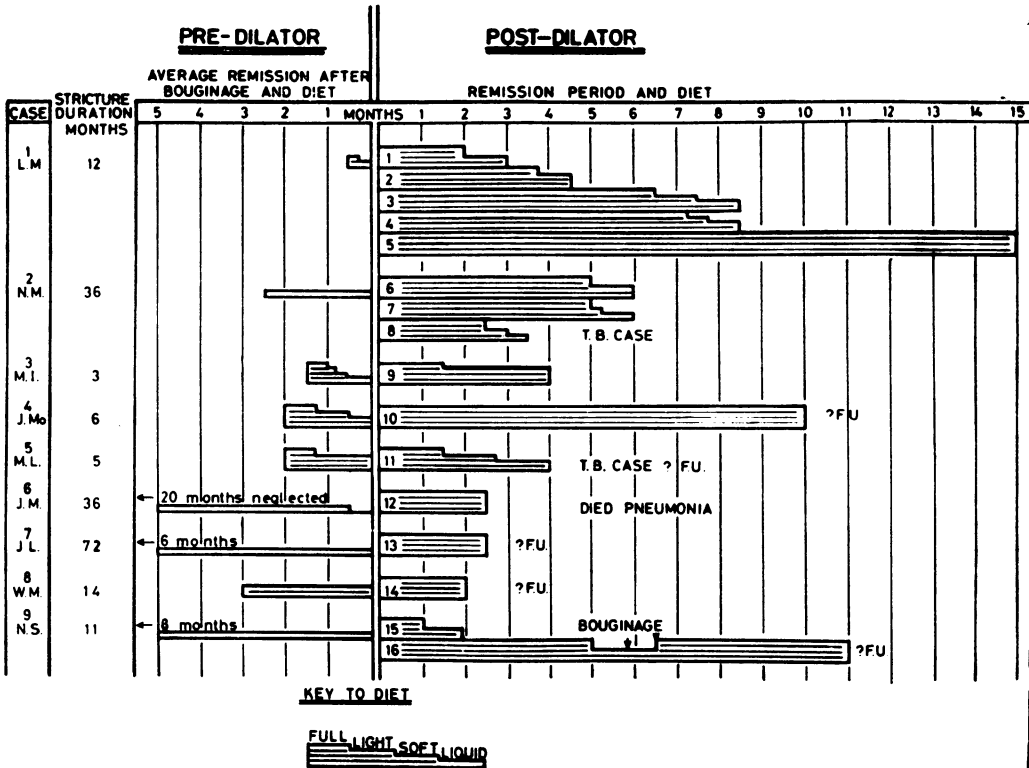


Fig. 6. Results of treatment with the dilator compared with bouginage alone in terms of remission periods after treatment and diet consumed. Soft diet includes white bread which has been softened in liquids; light diet includes mincemeat, dry bread, and soft vegetables; full diet includes all meats, vegetables, and fruit. ?FU = full follow-up not possible.

In most centres this patient would probably have required some form of oesophageal reconstruction, but it is doubtful now whether this will be necessary in her case if she is content to have these rather infrequent periods of dilatation. She has not as yet developed the complication of hiatus hernia from longitudinal fibrotic contracture or spasm as stressed by Allison² and Mullard³ respectively. However, it is interesting to observe that her stricture became shorter with treatment, and also the upper end moved from 25 cm initially to 28 cm at her last treatment.

Case 2 (N.M.) This patient, a woman of 26, was similar to the previous one in that she had suffered from a caustic stricture of 4 years' duration. During that time she had never been able to eat anything but a soft or liquid diet and had required repeated bouginage to maintain her swallowing, the average interval being 2½ months during the previous year.

Dilatation was carried out, again using small then larger dilators, after which she was able to take a completely full diet for periods of up to 5 months.

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During the later course of her management she contracted tuberculosis and then the remission period between dilations became less, which was disappointing. It was found that she had been taking her tablets of PAS and isoniazid in three doses daily. It may be that this contributed to the deterioration in her stricture, since PAS is an irritating substance and the tablets would tend to linger at the stricture site and cause some degree of ulceration, which might have contributed to more fibrosis. In support of this, during her second remission period she complained of burning pain between the shoulder blades, which was worse on swallowing. A further point of interest was that, as in Case 1, her stricture gradually moved down from 23 to 25 cm during the course of treatment.

Case 3 (M.I.) This patient, a man of 55, developed an anastomotic stricture between a colon graft and the lower oesophagus. This type of stricture should respond well to treatment with the dilator, especially if it is short and correctly shaped for stability. However, it was not treated ideally. A longer large

TABLE

This gives details of the diameter of the various dilators and their periods in the oesophagus prior to each remission. The numbers in the right-hand horizontal bars (1-16) in Fig 6 correspond with the numbers of the remissions.

<i>Case</i>	<i>Remission</i>	<i>Diameter of dilator used</i>	<i>Period the dilator remained in the oesophagus</i>	
1. L.M.	1	15 mm	3 days	
	2	25 mm	8 days	
	3	25 mm	28 days	
	4	{	20 mm	28 days
			25 mm	21 days
5		20 mm	14 days	
2. N.M.	6	{	10 mm	7 days
			20 mm	14 days
			25 mm	30 days
	7	{	15 mm	7 days
			20 mm	25 days
			30 mm	15 days
	8	{	20 mm	2 days
			20 mm	32 days
3. M.I.	9	25 mm	14 days	
4. J.Mo.	10	20 mm	1 day	
5. M.L.	11	{	12 mm	5 days
			22 mm	42 days
6. J.M.	12	20 mm	14 days	
7. J.L.	13	{	20 mm	4 days
			35 mm*	3 minutes
8. W.M.	14	{	15 mm	2 days
			20 mm	3 hours
9. N.S.	15	{	20 mm	80 days
			20 mm	30 days

*Before removing the dilator, a bulb catheter was inserted into the lumen and the bulb inflated to widen the dilator to 35 mm before removal to stretch in a similar way to a Plummer-Negus bag.

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dilator was the only one available and this was used. Unfortunately it was first placed too low and had to be reinserted higher up, thus causing some excoriation. This was before the use of the purse-string to aid removal. Surgical emphysema in the neck resulted from this, which settled in a few days on conservative treatment, but as the patient complained of discomfort the dilator was removed earlier than usual. He was able to take a normal diet for 1½ months, followed by a light diet for another 2 months. This represented more than a doubling of his remission period and a vast improvement in his diet. He rapidly put on weight and returned to work, but he was not referred for further treatment and continued to have infrequent bouginage when necessary. He succumbed eventually 1½ years later, apparently from a series of illnesses following a perforation of the oesophagus from bouginage.

This case illustrates a moderate result from poor technique—a better result could be expected with satisfactory use of the correct size of dilator. It also emphasizes the dangers of recurrent bouginage.

Case 4 (J.Mo.) A man aged 39, having suffered from a caustic stricture for 6 months, with bouginage on 5 occasions, was still able to eat only soft food. After the use of a 20-mm dilator for only 24 hours he could manage a normal diet, and when seen a year later he required no further treatment.

Case 5 (M.L.) A man aged 50 developed dysphagia after treatment for tuberculosis. Repeated biopsy showed no carcinoma, nor could tuberculosis be incriminated. The stricture was very irregular but was finally negotiated with a small metal object tied to a cotton thread and treatment carried out as outlined under 'tight or irregular strictures'. His remission, though fair, was not as long as expected—again perhaps related to his having to take antituberculosis tablets as in Case 2.

Case 6 (J.M.) A man of 42 had a tight anastomotic stricture in the neck at the site of gastropharyngostomy performed 3 years previously to bypass a caustic stricture. He could hardly swallow liquids and suffered from aspiration pneumonia, for which he required 2 weeks' treatment. After this a well-flared dilator was inserted for 2 weeks, which dilated the stricture sufficiently to allow a large oesophagoscope to be passed easily and a normal diet to be taken.

Unfortunately, when he was admitted to another unit for recurrent pneumonia 2 months later, this went on to lung abscess, from which he succumbed. However, he was still able to swallow well before death. In the absence of his cricopharyngeus sphincter his stomach contents tended to regurgitate, and there is little doubt that this precipitated the chest infection by aspiration, as he refused to sleep propped up.

Case 7 (J.L.) A man aged 50 had suffered from achalasia followed by recurrent stricture of the lower oesophagus following two Heller's operations performed 8 and 10 years before. Further wide myotomy was apparently under consideration as he had achieved only partial remission from recurrent bouginage, including the use of a Plummer-Negus bag.

A dilator was left in situ for 4 days and, just before removal, was found to have opened up to about 20 mm in diameter. The bulb of a catheter was inflated in the lumen of the dilator to about 30 mm diameter and held for 3 minutes, and then both were removed. After this he could eat normally for 2½ months but failed to report for further follow-up from a remote farm district.

Case 8 (W.N.) A woman of 30 had only a short period of treatment because the second dilator had to be removed after about 2 hours on account of

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an accident during insertion requiring a laparotomy (discussed under 'complications'). She was still eating normally when seen 6 weeks later, but could not be traced for further follow-up.

Case 9 (N.S.) This patient, a woman of 21, swallowed caustic soda, after which she could only take liquids, and 4 months later she could barely swallow at all. She managed for a while with a gastrostomy and finally, a year after her accident, a dilator was inserted and removed 2½ months later. A month later she again suffered dysphagia so it was reinserted for a further month. Thereafter she had no further trouble for 5½ months, when she was found to have developed a short oesophageal web which responded to dilatations with bougies twice. She remained well for the next 4 months, after which her record ends.

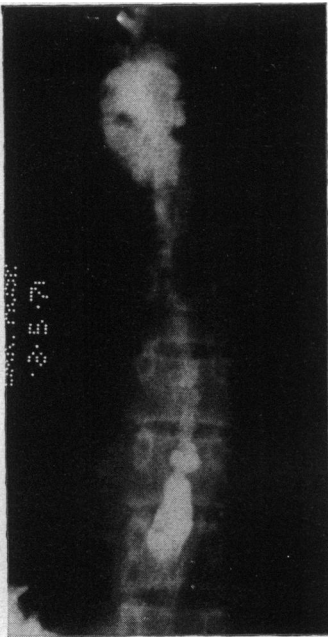


Fig. 7. Barium swallow showing long, tight, caustic stricture.

Why this patient should have had only one month's remission after the first dilatation is not clear. Perhaps the dilator had slipped slightly down the stricture and there was still a little part of the stricture left untreated above it which closed down after removal. Her subsequent course proved very satisfactory after the second insertion, apart from the brief period when she was bothered by an oesophageal web.

Complications

There have been no cases of perforation of the oesophagus due to the presence of the dilator itself in the benign series, but one stomach was perforated when the introducing tube was introduced too far owing to an error of calculation. This would not have occurred if X-ray control had been used, but with greater experience and the use of the graduated ramrod this should be unnecessary.

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Difficulty in removal of the dilator was a serious problem in the early cases, especially in Case 1. This problem has been overcome by the use of the purse-string in the mouth of the dilator.

Downward displacement of the dilator occurred 3 times. It was found that too small a dilator had been used which did not grip the stricture sufficiently firmly from within. The flanges were possibly insufficiently well developed, or the stricture was, at that stage, not very tight and

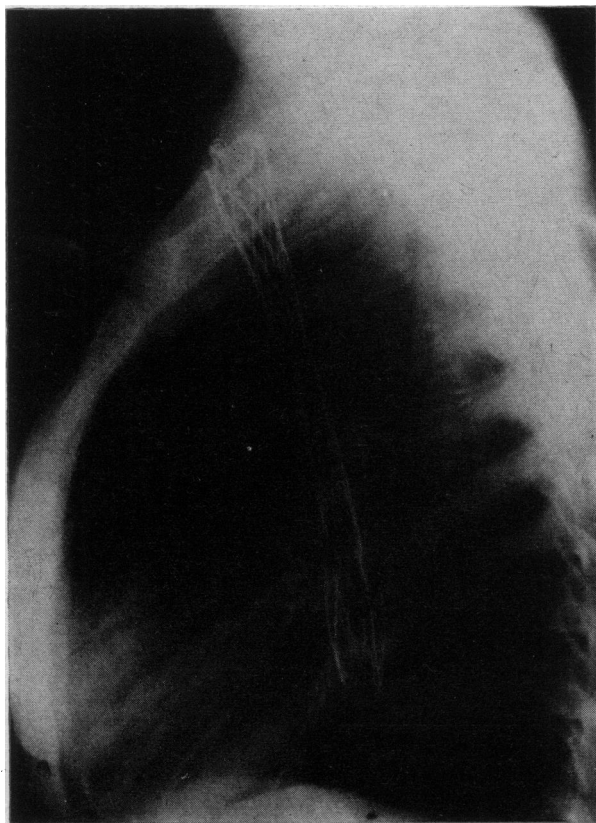


Fig. 8. Radiograph after insertion of dilator into previous caustic stricture, showing dilator in situ compressed.

the dilator used was not proportionately larger, as it should have been. The thread from dilator to nostril, as described under 'method of insertion', has also helped to prevent this complication.

In two cases the dilator was vomited up. In one of these the dilator was too small for the size of the stricture, and in the other, in which the dilator was vomited the following day, the stricture was not very tight and the dilator had a loose double sheath, both inside and out, and

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the space between the inner and outer sheaths became full of fluid. The dilator became obstructed and then, when vomiting occurred, acted as a piston which was shot out of the mouth! No further dilators were covered in this way and this complication has not occurred again.

Pain between the shoulder blades has been a common complaint in most cases, particularly in the first patient treated. It is normal for patients to have discomfort, usually localized at the site of the dilator, for the first couple of days. After the first 5-7 days the patients are

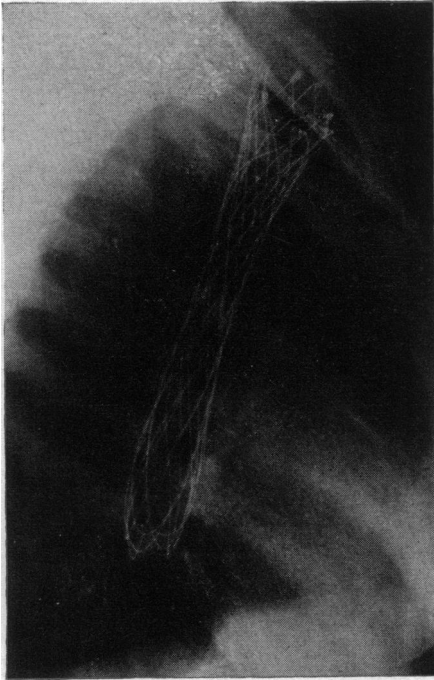


Fig. 9. Radiograph 5 days later in same patient, after dilator has expanded.

usually unaware of anything present in their oesophagus, except perhaps on coughing or swallowing. If pain becomes really severe the removal of the dilator is advised if it does not subside in a few hours.

The treatment of tuberculosis appears to interfere with the remission period, as in Cases 2 and 5.

Malignant stricture

Some 50 cases of inoperable carcinoma of the oesophagus have been treated (to be reported elsewhere) but several of these behaved as benign strictures initially in that X-ray treatment had temporarily retarded the growth and the subsequent stricture behaved more like fibrous tissue.

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These patients responded well to dilatation and several showed a good period of remission. All took normal diet after their tubes were removed, and in others the tube remained in situ for palliation.

The method appeared to be particularly valuable for strictures high in the oesophagus where ordinary bouginage was unsuccessful and where other tubes did not seem to be tolerated owing to their single wide flange. This dilator, if suitably tailored in terms of diameter, length, and bulbous ends, was well tolerated for periods of up to 2 weeks and achieved wide dilatation. One patient who had had cobalt therapy took a normal diet for over 5 months after his initial dilatation, thereafter requiring one or two periods of bouginage only. He was still alive a year later.

Complications were more numerous in the early stages of experience, but comparable to the series reported by other workers using tubes such as the Souttar, Mousseau-Barbin, Celestin, and Gourevitch tubes. Complications have been rare in the second half of the series.

It is now felt that this dilator has an advantage in these cases, simply because of the wide degree of dilatation which can be achieved whether the tube remains in or not. It may well be that the best combination is to use the dilator initially and then to replace it with the ideal soft, tailored tube merely to maintain patency afterwards, and here there is room for individual preference. Ideally the tube should be stable, comfortable, wide enough not to cause blockage, and, if possible, not cause reflux by transgressing the cardio-oesophageal junction. However, when it does so, some form of valve mechanism, it seems, should be employed. Here the Gourevitch tube, in the experience of MacArthur and Mercer⁴, has an advantage in that it can be angulated upwards so that its lower end rests in the gastric bubble, thus causing less reflux at night. Introduction of a second tube is always easily effected without laparotomy because of the wide dilated oesophageal lumen.

Discussion

Slow continuous dilatation with a sprung tube can achieve a degree of dilatation hitherto unobtainable. Two factors are important. Firstly the prolonged application of gentle pressure and secondly the wide diameter that can be reached by this tube, which is not limited by the size of the introducing oesophagoscope. The degree of dilatation can clearly be seen on penetrating radiographs taken at a standard 6-ft. (1.8-m) distance. This is shown in the accompanying radiographs (Figs. 7—10), in which dilatation is shown over a period of 5 days.

Slight excoriation and inflammation may be evident a few days after removal of the dilator, but the stricture is wide open so that usually the largest oesophagoscope can be passed right through it. In all cases the patient has been able to eat a normal diet. A light to full

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diet can be consumed while the dilator is in situ, depending on the patient's teeth. The period of normal diet seems to get progressively longer in patients who have recurrent treatment, except those who suffer from chronic diseases such as cancer or tuberculosis. Carefully graduated smaller and then larger sizes of dilators in the early stages in severe cases seem to give improved results.

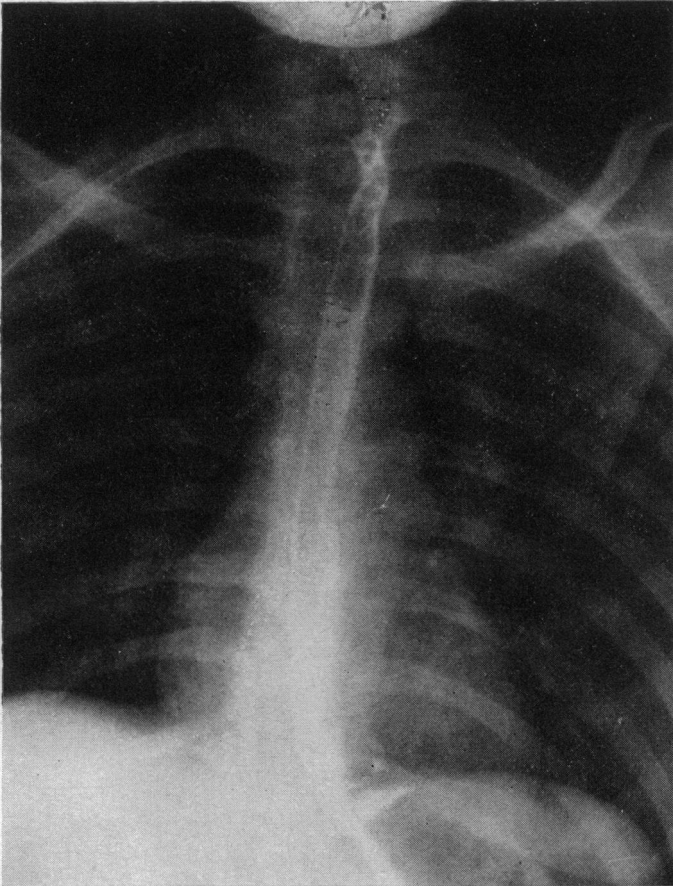


Fig. 10. Barium swallow after removal of dilator.

Pain for the first 2-3 days is the usual pattern. This gives way to discomfort, which usually disappears in about a week depending on the size of the dilator and its height in the oesophagus. Generally, the higher the position the more uncomfortable it is.

As knowledge of the method has increased, insertion and removal have become straightforward procedures. There has been no mortality

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and no perforations of the oesophagus on account of the tube itself in the benign series or the latter half of the malignant series. The dangers of the method are mainly limited to the bouginage and introduction. When a gastrostomy is present the railroad method of introduction is used by preference when bouginage is hazardous.

Stability of the tube in position has been found to be related to use of the correct size of dilator in relation to the stricture, so that it grips adequately from within while the well-formed bulbous ends are in normal oesophagus.

In carcinoma palliation the dilator has the advantage of the Souttar tube which, as advocated by Collis⁵, can be inserted without laparotomy. In addition the wide dilatation improves swallowing. It is particularly valuable in sealing off a tracheo-oesophageal fistula.

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REFERENCES

1. HARRISON, D. F. N. (1972) *Annals of the Royal College of Surgeons of England*, 51, 120.
2. ALLISON, P. R. (1951) *Surgery, Gynecology and Obstetrics*, 92, 419.
3. MULLARD, K. S. (1972) *Annals of the Royal College of Surgeons of England*, 50, 90.
4. MACARTHUR, A., and MERCER, T. L. (1969) *Thorax*, 24, 39.
5. COLLIS, J. L. (1972) *Annals of the Royal College of Surgeons of England*, 50, 306.