

The Use of Metallic Stents in the Palliation of Inoperable Oesophageal Carcinoma

B S Tan,**FAMS, MBBS, FRCR*

Abstract

Carcinoma of the oesophagus is the seventh most common malignancy worldwide. It is a disease with a poor prognosis; more than half of the patients present with surgically irresectable tumours. For such patients, palliative therapy is directed towards the relief of dysphagia. Expandable metallic stents have recently been developed for use in the oesophagus. These have the advantage of being introduced through small diameter delivery catheters. Once released, they can expand to as much as 25 mm in diameter, potentially allowing patients to consume a normal diet. The current designs of metallic stents include the Strecker stent, the Wallstent endoprosthesis, and the Gianturco-Rosch stent. The Strecker is an uncovered stent while the other two are covered on the outside of the stent with plastic to prevent tumour ingrowth.

A review of the literature indicates that deployment of these stents is associated with a high technical success rate. Improvement in swallowing function is seen in 83% to 100% of these patients. The overall complication rates are low. However, covered stents are prone to migration while uncovered stents are vulnerable to tumour ingrowth. Further improvements in design promise to expand the role of these endoprotheses in the management of oesophageal carcinoma.

Ann Acad Med Singapore 1997; 26:344-9

Key words: Dysphagia, Endoprosthesis, Fistula, Stricture

Introduction

Oesophageal carcinoma ranks as the seventh most common malignancy worldwide.¹ In Singapore, it has an incidence rate of 5.9 per 100 000 among males and a rate of 2.2 per 100 000 among the female population.² It is a disease with a poor prognosis with more than half of the patients having surgically irresectable tumours at presentation.^{3,4} For these patients, the main aim of management is palliation and this revolves around the relief of dysphagia. Various techniques have been utilised and these include surgery, radiotherapy, chemotherapy, and endoscopic interventional methods like laser therapy, alcohol injection and bipolar electrocoagulation.

Surgical resection or bypass is associated with a high mortality and morbidity³⁻⁶ and is therefore not a viable option for palliation. External radiotherapy yields sustained response rates of about 50%, requires several weeks to take effect and is subsequently complicated by formation of fibrotic strictures in about 30%.⁷⁻¹¹ Combination radiotherapy and chemotherapy have shown more promising results, but at the expense of significantly higher toxicity.¹²⁻¹⁶ The endoscopic methods of intervention can achieve response rates of about 80% but require the patient to return regularly for repeated procedures to maintain their effect.¹⁷⁻²⁷

Clearly the ideal palliative procedure should achieve its objective in a single procedure with minimal discomfort and morbidity, and should have a sufficiently sustained effect during the patient's remaining life without requiring further intervention.

Oesophageal Stents

The concept of a stent to mechanically maintain the lumen of the oesophagus to allow swallowing thus attempts to meet this objective of palliation. Unlike radiation therapy, endoscopic laser or alcohol therapy, it is essentially a one-step procedure. Unfortunately, the initial designs made from plastic were fraught with problems. The earlier stents were very rigid and had to be inserted via an open surgical procedure, at the cost of increased morbidity and mortality.^{28,29} Subsequent designs could be inserted via endoscopy under general anaesthesia although some operators perform this procedure with intravenous sedation.³⁰⁻³²

As these stents were made of plastic, there was relatively poor lumen-to-wall ratio. For example, a plastic stent with an outer diameter of 16 mm would only have a luminal diameter of 12 mm. As a result, the majority of patients were unable to consume a normal diet and could only manage a liquidized one. Furthermore, the procedure-related morbidity was quite significant, with

* Senior Registrar,
Department of Diagnostic Radiology
Singapore General Hospital

Address for Reprints: Dr Tan Bien Soo, Department of Diagnostic Radiology, Singapore General Hospital, 1 Hospital Drive, Singapore 169608

complications occurring in as many as 36% of patients and a procedure-related mortality of 2% to 16%.³⁰⁻³⁶

A recent development in stent technology has addressed these problems inherent in plastic prostheses. Expandable metallic stents, initially designed for use in the vascular system and biliary tree have been adapted for use in the oesophagus. The concept behind the use of metallic stents is that they can be introduced in a compressed state within a small diameter delivery catheter, but when released, they expand to a much larger diameter. The procedure of insertion therefore becomes safer as the stricture does not need to be predilated to such large diameters. The patients are also potentially able to take a normal diet as these endoprotheses have luminal diameters ranging from 18 to 25 mm. The first report on the use of a metallic stent in the oesophagus was published in 1990 and since then numerous reports documenting the results of these stents have appeared in the literature.³⁷

A prospective, randomised trial of 42 patients comparing a plastic stent with an expandable metallic

prosthesis in the palliation of malignant dysphagia was reported in 1993.³⁸ The plastic stent had a luminal diameter of 12 mm and an outer diameter of 16 mm (Wilson-Cook, Winston-Salem, NC, USA), with a pusher catheter of 54 F size (Fig. 1). This was introduced using endoscopic and fluoroscopic guidance under general anaesthesia. The metallic stent was a prototype uncovered Wallstent (Schneider AG, Zurich, Switzerland) 16 mm in diameter, and was deployed with the patient under intravenous sedation. The dysphagia scores improved to a similar degree in both groups of patients, but there were significantly more complications in the group with plastic prostheses (9 versus none). Three procedure-related deaths occurred in the plastic prostheses group, 2 from perforation and one from aspiration pneumonia. The total hospital stay of the plastic prostheses group was also significantly longer. The authors concluded that although the initial cost of a metallic stent was 10 times more than that of a plastic one, the use of the metallic endoprotheses would be cost effective provided the cost of hospitalisation exceeded US\$193 per day. The adaptation of these figures would of course depend on local circumstances. In Singapore, the cost of a metallic stent is approximately 6 times that of a plastic one.

Types of Metallic Stents

There are currently 3 types of commercially available metallic stents in Singapore. They are the Strecker stent (Boston Scientific Corporation, Watertown, MA, USA), the Wallstent endoprosthesis (Schneider AG, Zurich, Switzerland) and the Gianturco-Rosch stent (William Cook Europe, Bjaeverskov, Denmark).

Unlike the other two, the Strecker stent (also known as the Ultraflex stent) is an uncovered device. It consists of nitinol wire knitted into a tubular mesh with a diameter of 18 mm. The proximal end of the stent is flared to a diameter of 20 mm to prevent distal migration (Fig. 2). The stents are manufactured in lengths of 7, 10 and 15 cm and the delivery device is 24 F in size.³⁹

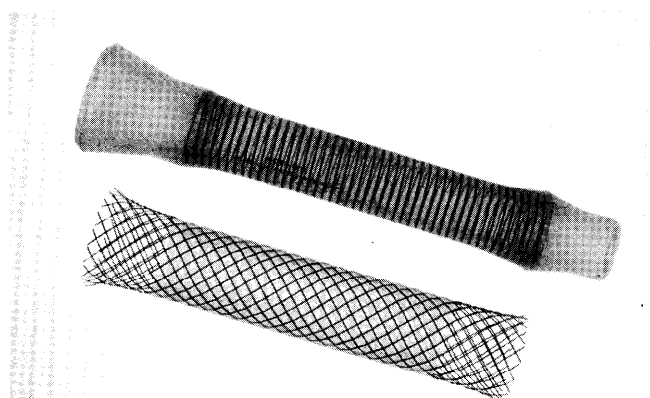


Fig. 1. Comparison between a plastic and a metallic stent.

Fig. 1(a). A Wilson-Cook plastic stent of 16 mm outer diameter and 12 mm luminal diameter (top) and a Wallstent endoprosthesis of 20 mm diameter (bottom).

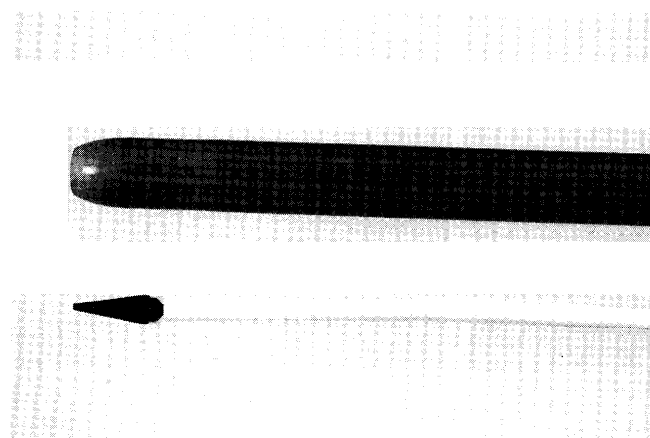


Fig. 1(b). The 54 F pusher required to deploy the plastic stent (top) compared to the significantly smaller Wallstent delivery device which is of 18 F size (bottom).

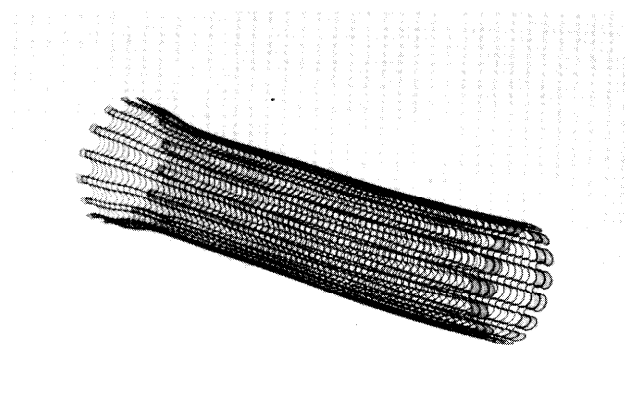


Fig. 2. The Strecker stent.

The Wallstent endoprosthesis is made of a tubular mesh of surgical grade stainless steel alloy filaments. It is manufactured in 2 diameters, 25 and 20 cm, with lengths of 10.5 cm and 11 cm respectively. The middle 7 cm of the stent is covered on the outside with a layer of polyurethane to prevent tumour ingrowth (Fig. 1). The delivery catheter is 22 F in size for the larger diameter stent and 18 F for the smaller one.⁴⁰

The Gianturco-Rosch stent is constructed from stainless steel wire bent in a zig-zag fashion to form a tube. It is 18 mm in diameter with the proximal end flared to 22.5 mm and is available in lengths of 10, 12 or 14 cm. To prevent tumour ingrowth, it is covered on the outside with polyethylene throughout its length (Fig. 3). There

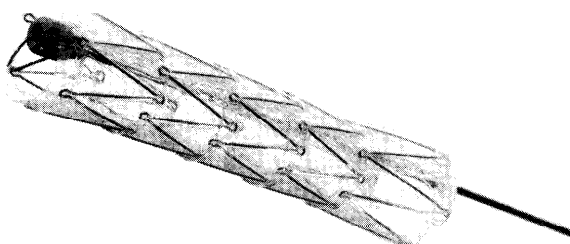


Fig. 3. The Gianturco-Rosch stent.

are small barbs present externally to prevent stent migration. The delivery device is 24 F in size.⁴¹

Technique of Stent Deployment

The procedure is performed solely under fluoroscopic guidance. Endoscopy is only necessary in very high strictures where the level of the cricopharyngeus muscle has to be marked. Some centres routinely utilise endoscopy in addition to fluoroscopic guidance, but this only serves to increase the cost of the procedure. A barium swallow is performed one day before the procedure to demarcate the site and extent of the stricture (Fig. 4). The patient is then fasted for 6 hours prior to the procedure.

For the procedure, the patient is placed in a left lateral position and connected to a pulse oxymeter and blood pressure cuff. Intranasal oxygen is routinely administered. The oropharynx is anaesthetised with a lidocaine hydrochloride spray and intravenous sedation administered.

Under fluoroscopic guidance, a standard angiographic catheter and guide wire are introduced per-orally and positioned just above the stricture. Non-ionic water-soluble contrast media is then injected to demonstrate the stricture. The catheter and guide wire are then manipulated past the tumour down the oesophagus and into the stomach. If the distal extent of the lesion could not be demonstrated initially, further contrast medium is injected with the catheter below the stricture so that its full length is delineated. This information is crucial for

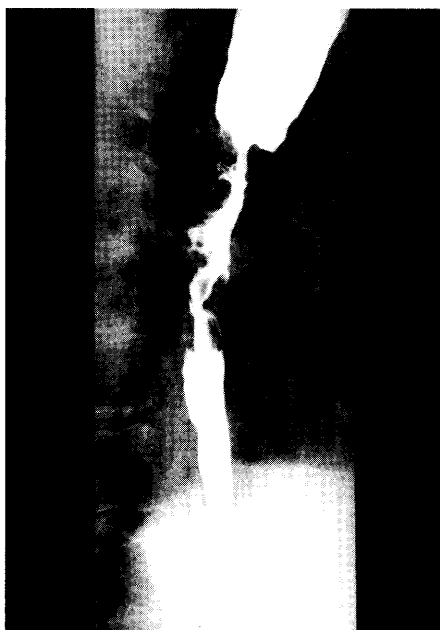


Fig. 4(a).



Fig. 4(b).

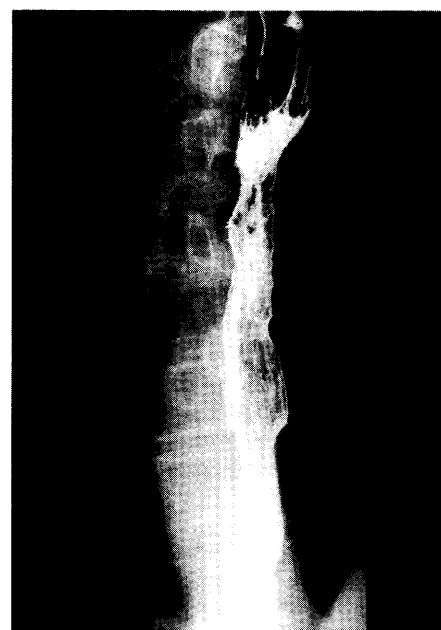


Fig. 4(c).

Fig. 4. A 75-year-old woman with squamous cell carcinoma of the mid oesophagus with cervical nodal metastases. She was only able to take a liquid diet.

Fig. 4(a). Barium swallow delineating site and extent of the stricture.

Fig. 4(b). A 10 cm long Strecker stent deployed across the stricture.

Fig. 4(c). Barium swallow the following day demonstrated free flow of barium through the stent down the oesophagus. She was able to consume a normal diet after the procedure.

the optimal placement of the stent. The stricture is then dilated using a balloon catheter up to 15 mm diameter.

The respective delivery device is then advanced 'over the guide wire across the stricture and positioned such that the mid point of the stent is slightly above the mid point of the stricture. This is to compensate for the effect of peristalsis which would tend to displace the prosthesis distally. Wherever possible, the stent should also be positioned such that its distal end is above the cardio-oesophageal junction to avoid the problems associated with reflux. After release of the endoprosthesis, contrast medium is injected down the oesophagus via the angiographic catheter to confirm the position of the stent and to exclude any perforation.

The patient is allowed clear fluids after a few hours and a barium swallow is performed the following day to assess the expansion of the stent. If there is suboptimal expansion of the prosthesis, it can be dilated with a balloon catheter. This is more so with the Strecker stent, which has the lowest radial force of the 3 designs. The patient is then given dietary advice, namely to chew food well before swallowing and not to take large pieces of meat or bread. A fizzy drink after meals will also help to wash any food residue down into the stomach. Where a stent has been deployed with its distal end within the stomach, antireflux measures including medical therapy are prescribed.

Results

There has been a plethora of reports on the use of

metallic stents in oesophageal carcinoma in the recent literature. An analysis of 8 of these reports (a total of 348 patients) revealed a technical success rate of 100% with improvement in swallowing function in 83% to 100% of patients.^{39,40,42-48} Three of the series referred to the Gianturco-Rosch stent, 3 to the Strecker, one to the Wallstent endoprosthesis and one included both Wallstent and Strecker stents. All the procedures were performed under conscious sedation with low complication rates. As the different stents had different characteristics, they were prone to different complications.

The covered stents (the Gianturco-Rosch and the Wallstent endoprostheses) were prone to migration, with 10% to 25% of the devices having complete or partial migration.^{40,42-44} This was especially so when the stents extended across the cardio-oesophageal junction into the stomach. This problem can be partially solved by early detection of migration on the 24-hour barium study. If migration is demonstrated, the first stent can be anchored by deploying a second device overlapping the first either proximally or distally, depending upon the direction of migration. This will of course increase the overall cost of the procedure and therefore accurate placement of the first stent is crucial.

On the other hand, the Strecker stent, being uncovered, was vulnerable to tumour ingrowth. This occurred in 16% to 30% of cases on follow-up.^{39,45,46} However, this problem can be dealt with either by balloon dilatation or laser therapy. Migration was not a prob-

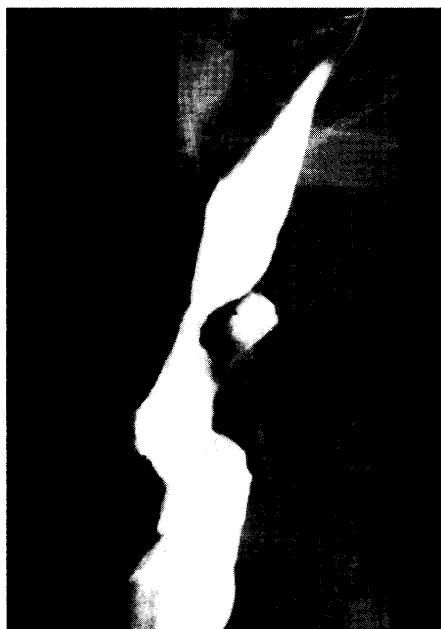


Fig. 5(a).



Fig. 5(b).

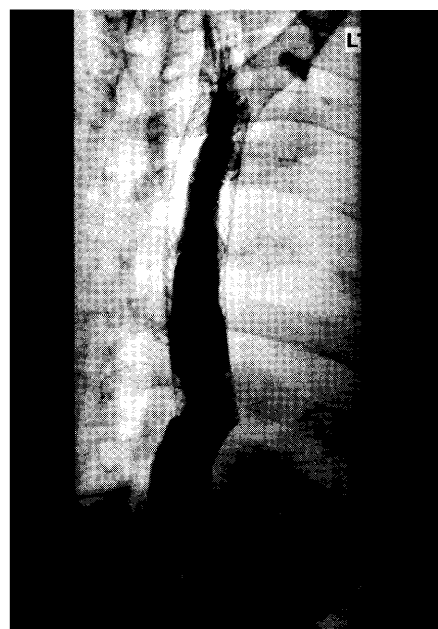


Fig. 5(c).

Fig. 5. A 50-year-old man with an oesophago-bronchial fistula as a result of a squamous cell carcinoma of the mid oesophagus.

Fig. 5(a). Barium swallow demonstrating the stricture and the fistula (arrow).

Fig. 5(b). A covered Wallstent endoprosthesis was deployed across the stricture.

Fig. 5(c). Barium swallow the following day showed successful sealing of the fistula.

lem with this device.

A prospective, triple-randomised trial comparing laser therapy, Wallstent endoprotheses and Strecker stents for the palliation of inoperable oesophageal carcinoma has been reported.⁴⁹ The study showed that both types of endoprotheses achieved significantly better swallowing function compared to laser therapy. The complication rates of each modality of treatment were equivalent but the nature of the complications differed between the 2 types of stents as described above.

Malignant Oesophageal Fistulae or Perforation

Approximately 5% of patients with carcinoma of the oesophagus develop a fistula with the respiratory tree. This is a condition with a high mortality; the median survival time in a series of 207 patients was 35 days.⁵⁰ Perforation of the oesophagus can also occur as a result of intervention.

Covered metallic stents (Fig. 5) have been reported to achieve successful sealing of these fistulae or perforations in 66% to 100% of cases.^{44,51-56} This was associated with a low procedural complication rate and a shorter hospital stay compared to conservative treatment. In view of the limited treatment options available to these patients, stenting is being advocated as the treatment of choice for this condition.

Conclusion

The development of expandable metallic stents has marked a significant step forward in the palliative treatment of patients with advanced oesophageal carcinoma. However, the current available stents are clearly not perfect and we can expect to see improvements in their design. The Strecker stent now has a covered version to prevent tumour ingrowth.⁵⁷ Proposed modifications to the current covered endoprotheses include placing of the plastic covering of the stent on the inside rather than externally to reduce the incidence of migration.

There is also ongoing research into new ways of inhibiting growth of tumour through the mesh of metallic stents. These ideas range from the development of an electrolytic stent, which generates a small electrical voltage to prevent tumour ingrowth, to coating of the metal filaments with angiogenesis inhibitors.^{58,59} With these developments, the role of metallic stents in the management of oesophageal carcinoma promises to expand further.

REFERENCES

- Parkin D M, Laara E, Muir C S. Estimates of the worldwide frequency of sixteen major cancers in 1980. *Int J Cancer* 1988; 41:184-97.
- Chia K S, Lee H P, Seow A, Shanmugaratnam K. Trends in Cancer Incidence in Singapore 1968-1992. Report No. 4. Singapore: Singapore Cancer Registry, 1996.
- Earlam R, Chunha-Melo J R Jr. Oesophageal squamous cell carcinoma: 1. A critical review of surgery. *Br J Surg* 1980; 67:381-90.
- Muller J M, Erasmi H, Stelzner M, Zieren U, Pichlmaier H. Surgical therapy of oesophageal carcinoma. *Br J Surg* 1990; 77:845-57.
- Altorki N K, Girardi L, Skinner D B. Squamous cell carcinoma of the esophagus: therapeutic dilemma. *World J Surg* 1994; 18:308-11.
- Lerut T E, Leyn P, Coosemans W, Van Raemdonck D, Cuypers P, van Cleynenbreughel B. Advanced esophageal carcinoma. *World J Surg* 1994; 18:379-87.
- Earlam R, Chunha-Melo J R. Oesophageal squamous cell carcinoma: II. A critical review of radiotherapy. *Br J Surg* 1990; 67:457-61.
- Caspers R J L, Welvaart K, Verkes R J, Hermans J, Leer J W H. The effect of radiotherapy on dysphagia and survival in patients with esophageal cancer. *Radiother Oncol* 1988; 12:15-23.
- Leslie M D, Dische S, Saunders M I, Grosch E, Fermont D, Ashford R F U, et al. The role of radiotherapy in carcinoma of the thoracic oesophagus: an audit of the Mount Vernon experience 1980-1989. *Clin Oncol* 1992; 4:114-8.
- Petrovich Z, Langholz B, Formati S, Luxton G, Astrahan M. Management of carcinoma of the esophagus: the role of radiotherapy. *Am J Clin Oncol* 1991; 14:80-6.
- O'Rourke I C, Tiver K, Bull C, Gebiski V, Langlands A O. Swallowing performance after radiation therapy for carcinoma of the esophagus. *Cancer* 1988; 61:2022-6.
- Herskovic A, Martz K, Al-Sarraf M, Leichman L, Brindle J, Vaitkevicius V, et al. Combined chemotherapy and radiotherapy compared to radiotherapy alone in patients with cancer of the esophagus. *N Engl J Med* 1992; 326:1593-8.
- Poplin E A, Khanuja P S, Kraut M J, Herskovic A M, Lattin P B, Cummings G, et al. Chemoradiotherapy of esophageal carcinoma. *Cancer* 1994; 74:1217-24.
- Le Prise E A, Meunier B C, Etienne P L, Julienne V C, Gedouin D M, Raoul J L, et al. Sequential chemotherapy and radiotherapy for patients with squamous cell carcinoma of the esophagus. *Cancer* 1995; 75:430-4.
- Urba S G, Turrisi A T. Split-course accelerated radiation therapy combined with carboplatin and 5-fluorouracil for palliation of metastatic or unresectable carcinoma of the esophagus. *Cancer* 1995; 75:435-9.
- Coia L R, Soffen E M, Schultheiss T E, Martin E E, Hanks G E. Swallowing function in patients with esophageal cancer treated with concurrent radiation and chemotherapy. *Cancer* 1993; 71:281-6.
- Fleischer D, Kessler F, Haye O. Endoscopic Nd:YAG laser therapy for carcinoma of the esophagus: a new palliative approach. *Am J Surg* 1982; 143:280-3.
- Bown S G, Hawes R, Matthewson K, Swain C P, Barr H, Boulos P B, et al. Endoscopic laser palliation for advanced malignant dysphagia. *Gut* 1987; 28:799-807.
- Krasner N, Barr H, Skidmore C, Morris I A. Palliative laser therapy for malignant dysphagia. *Gut* 1987; 28:792-8.
- Mason R C, Bright N, McColl I. Palliation of malignant dysphagia with laser therapy: predictability of results. *Br J Surg* 1991; 78:1346-7.
- Tytgat G N J. Endoscopic therapy of esophageal cancer: possibilities and limitations. *Endoscopy* 1990; 22:263-7.
- Rau B K, Harikrishnan K M, Krishna S. Oesophageal carcinoma: laser palliation in 231 cases. *Ann Acad Med Singapore* 1994; 23:32-4.
- Johnston J H, Fleischer D, Petrini J, Nord H J. Palliative bipolar electrocoagulation therapy of obstructing esophageal cancer. *Gastrointest Endosc* 1987; 33:349-53.
- Jensen D M, Machicado G, Randall G, Tung L A, English-Zych S. Comparison of low-power YAG laser and BICAP tumor probe for palliation of esophageal cancer strictures. *Gastroenterology* 1988; 94:1263-70.
- Fleischer D. A comparison of endoscopic laser therapy and BICAP tumor probe therapy for esophageal cancer. *Am J Gastroenterol* 1987; 82:608-12.
- Spiller R C, Misiewicz J J. Ethanol-induced tumour necrosis for palliation of malignant dysphagia. *Lancet* 1987; 2:792.
- Chung S C S, Leong H T, Choi C Y C, Leung J W C, Li A K C. Palliation of

- malignant oesophageal obstruction by endoscopic alcohol injection. *Endoscopy* 1994; 26:275-7.
28. Lishman A H, Dellipiani A W, Devlin H B. The insertion of oesophagogastric tubes in malignant oesophageal strictures: endoscopy or surgery? *Br J Surg* 1980; 80:257-9.
 29. Watson A. A study of the quality and duration of survival following resection, endoscopic intubation and surgical intubation in oesophageal carcinoma. *Br J Surg* 1982; 69:585-8.
 30. Atkinson M, Ferguson R. Fiberoptic endoscopic palliative intubation of inoperable oesophagogastric neoplasms. *BMJ* 1977; 1:266-7.
 31. Atkinson M, Ferguson R, Parker G C. Tube introducer and modified Celestin tube for use in palliative intubation of oesophagogastric neoplasms at fiberoptic endoscopy. *Gut* 1978; 19:669-71.
 32. Den Hartog Jager F C A, Bartelsman J F W M, Tytgat G N J. Palliative treatment of obstructing esophagogastric malignancy by endoscopic positioning of a plastic prosthesis. *Gastroenterology* 1979; 77:1008-14.
 33. Gasparri G, Casalegno P A, Camandona M, Del Poli M, Salizzoni M, Ferrarotti G, et al. Endoscopic insertion of 248 prostheses in inoperable carcinoma of the esophagus and cardia: short-term and long-term results. *Gastrointest Endosc* 1987; 33:354-6.
 34. Fugger R, Niederle B, Jantsch H, Schiessel R, Schulz F. Endoscopic tube implantation for the palliation of malignant esophageal stenosis. *Endoscopy* 1990; 22:101-4.
 35. Liakakos T K, Ohri S K, Townsend E R, Fountain S W. Palliative intubation for dysphagia in patients with carcinoma of the esophagus. *Ann Thorac Surg* 1992; 53:460-3.
 36. Spinelli I, Cerrai F G, Ciuffi M, Ignomirelli O, Meroni E, Pizzetti P. Endoscopic stent placement for cancer of the lower esophagus and gastric cardia. *Gastrointest Endosc* 1994; 40:455-7.
 37. Domschke W, Foerster E C, Matek W, Rodl W. Self-expanding mesh stent for esophageal cancer stenosis. *Endoscopy* 1990; 22:134-6.
 38. Knyrim K, Wagner H J, Bethge N, Keymling M, Vakil N. A controlled trial of an expansile metal stent for palliation of esophageal obstruction due to inoperable cancer. *N Engl J Med* 1993; 329:1302-7.
 39. Cwikiel W, Stridbeck H, Tranberg K, von Holstein C S, Hambræus G, Lillo-Gil R, et al. Malignant esophageal strictures: treatment with a self-expanding nitinol stent. *Radiology* 1993; 187:661-5.
 40. Watkinson A F, Ellul J, Entwisle K, Mason R C, Adam A. Esophageal carcinoma: initial results of palliative treatment with covered self-expanding endoprostheses. *Radiology* 1995; 195:821-7.
 41. Nicholson A A, Royston C M S, Wedgewood K, Milkins R, Taylor A D. Palliation of malignant oesophageal perforation and proximal oesophageal malignant dysphagia with covered metal stents. *Clin Radio1* 1995; 50:11-4.
 42. Saxon R R, Barton R E, Katon R M, Petersen B D, Lakin P C, Timmermans H, et al. Treatment of malignant esophageal obstructions with covered metallic Z stents: long-term results in 52 patients. *J Vasc Interv Radio1* 1995; 6:747-54.
 43. Song H Y, Do Y S, Han Y M, Sung K B, Choi E K, Sohn K H, et al. Covered, expandable esophageal metallic stent tubes: experiences in 119 patients. *Radiology* 1994; 193:689-95.
 44. Miyayama S, Matsui O, Kadoya M, Yoshikawa J, Gabata T, Kitagawa K, et al. Malignant esophageal stricture and fistula: palliative treatment with polyurethane-covered Gianturco stent. *J Vasc Interv Radio1* 1995; 6:243-8.
 45. May A, Selmaier M, Hochberger J, Gossner L, Muhldorfer S, Hahn E G, et al. Memory metal stents for palliation of malignant obstruction of the esophagus and cardia. *Gut* 1995; 37:309-13.
 46. Winkelbauer F W, Schofl R, Niederle B, Wildling R, Thurnher S, Lammer J. Palliative treatment of obstructing esophageal cancer with nitinol stents: value, safety and long-term results. *Am J Roent* 1996; 166:79-84.
 47. Goh P Y T, Wong D E S, Chee S G. Radiological stenting of malignant oesophageal strictures: the Singapore experience. *Minimally Invasive Ther Allied Technol* 1996; 5:464-70.
 48. Tan B S, Mason R C, Adam A. Minimally invasive therapy for advanced oesophageal malignancy. *Clin Radio1* 1996; 51:828-36.
 49. Adam A, Ellul J, Watkinson A F, Tan B S, Morgan R A, Saunders M P, et al. Palliation of inoperable esophageal carcinoma: a prospective randomized trial of laser therapy and stent placement. *Radiology* 1997; 202:344-8.
 50. Burt M J, Diehl W, Martini N, Bains M S, Ginsberg R J, McCormack P M, et al. Malignant esophagorespiratory fistula: management options and survival. *Ann Thorac Surg* 1991; 52:1222-9.
 51. Do Y S, Song H Y, Lee B H, Byun H S, Kim K H, Chin S Y, et al. Esophagorespiratory fistula associated with esophageal cancer: treatment with a Gianturco stent tube. *Radiology* 1993; 187:673-7.
 52. Watkinson A, Ellul J, Entwisle K, Farrugia M, Mason R, Adam A. Plastic-covered metallic endoprostheses in the management of oesophageal perforation in patients with oesophageal carcinoma. *Clin Radio1* 1995; 50:304-9.
 53. Weigert N, Neuhaus H, Rosch T, Hoffman W, Dittler H J, Classen M. Treatment of esophagorespiratory fistulas with silicone-coated self-expanding metal stents. *Gastrointest Endosc* 1995; 41:490-6.
 54. Saxon R R, Barton R E, Katon R M, Lakin P C, Timmermans H S, Uchida B T, et al. Treatment of malignant esophagorespiratory fistulas with silicone-covered metallic Z stents. *J Vasc Interv Radio1* 1995; 6:237-42.
 55. Bethge N, Sommer A, Vakil N. Treatment of esophageal fistulas with a new polyurethane covered, self-expanding mesh stent: a prospective study. *Am J Gastroenterol* 1995; 90:2143-6.
 56. Mohammed S, Moss J. Palliation of malignant tracheo-oesophageal fistula using covered metal stents. *Clin Radio1* 1996; 51:42-6.
 57. Strecker E I, Boos I, Vetter S, Strohm M, Domschke S. Nitinol esophageal stents: new designs and clinical indications. *Cardiovasc Interv Radio1* 1996; 19:15-20.
 58. Cwikiel W. Development of an electrolytic stent: an experimental study in rats and pigs [abstract]. *Cardiovasc Interv Radio1* 1996; 19(suppl 2):53.
 59. Machan L S, Hunter W, Arsenaault L, Demetrik J. Angiogenesis inhibitor as a means for preventing stent overgrowth [abstract]. *Cardiovasc Interv Radio1* 1996; 19(suppl 2):54.