Endoscopic biliary drainage
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A prospective randomised trial of tannenbaum type teflon coated stents versus polyethylene stents for distal malignant biliary obstruction


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TANNENBAUM TYPE TEFLON COATED VERSUS POLYETHYLENE STENTS 77

ABSTRACT

Objective: Stent clogging is a major limitation in the palliative treatment of malignant biliary obstruction. Preliminary studies suggested improved duration of patency of a Tannenbaum design stent with a stainless steel mesh and an inner Teflon coating (TTC). We compared the patency of a TTC stent to conventional polyethylene (PE) stent in a prospective randomised trial.

Methods: Between February 1998 and September 1998 we included 60 patients with distal malignant bile duct obstruction. Diagnosis included carcinoma of the pancreas (N=57) and ampullary cancer (N=3). There were 29 men 31 women with a median age of 77 years. Stent diameter (10 Fr) and length (9 cm) were similar but both stent design and material were different: a Tannenbaum design stent with a stainless steel mesh and an inner Teflon coating and an Amsterdam type Polyethylene stent.

Results: Sixty patients were evaluated; thirty in the TTC and thirty the PE group. Early complications occurred in two patients in each group. Stent dysfunction occurred in eighteen of TTC and twelve of PE stents. Median stent patency was 102 days for TTC and 142 days for PE stents (p= 0.41). Median survival did not differ significantly for both treatment groups (TTC 121 days, PE 105 days). Stent migration, in all cases proximal into the common bile duct, occurred in 4 patients in the TTC group versus zero in the PE group (p=0.038).

Conclusions: This study did not confirm improved patency of Tannenbaum type Teflon coated stents. Proximal migration prompts for additional design modifications.

INTRODUCTION

Biliary stent insertion has become a standard palliative treatment for obstructive jaundice caused by malignancy of the pancreas and biliary system. The standard plastic stent currently used is the Amsterdam type polyethylene stent with a median patency of 3-6 months (1-5).

Changing the properties of materials used in the manufacturing process of plastic stents has been explored as a means to improve stent patency. In vitro studies performed by our group have demonstrated a direct relation between the frictional coefficient of a polymer and the amount of encrusted material (6). On these experimental grounds, Teflon appears to be the best polymer for biliary stents.

In a non-randomised study Soehendra evaluated a Tannenbaum design Teflon stent and showed a median stent patency of 15 months (7). Until now these encouraging results have not been confirmed in three multi-center randomised trials (8-10). A preliminary study by Abedi and co-workers suggested improved duration of patency of a Tannenbaum design stent with a stainless steel mesh between an inner Teflon coating and an outer polyamide layer (11). Mean stent patency was 134 days and no occlusions were noted.
We conducted a prospective randomised trial to compare the patency rate of a conventional polyethylene stent (PE) to a Tannenbaum design stent with a stainless steel mesh between an inner Teflon coating and an outer polyamide layer (TTC) in patients with an irresectable distal malignant bile duct stricture.

PATIENTS AND METHODS
Criteria for eligibility
Patients were included if they had obstructive jaundice due to an irresectable malignancy involving the distal bile duct without having undergone a previous drainage procedure. Diagnosis of malignancy was based on clinical and imaging findings. No other therapy was used to relieve biliary obstruction during the study period. The study protocol was approved by the local ethics committee. All patients gave informed consent prior to entry in the study.

Treatment
A diagnostic ERCP was performed to assess biliopancreatic anatomy. When deep cannulation was successful and cholangiography showed a distal common bile duct stricture, patients were randomised. Randomisation was performed by computer generated random numbers in sealed envelopes. Stenting was carried out using standard techniques (12).

Follow-up and definition of end points
Patients were interviewed by telephone at monthly intervals until stent obstruction, death, surgical treatment or the end of the follow-up period in April 1999. Stent drainage was considered to be successful if serum bilirubin dropped more than 20% within one week after stent insertion. If jaundice failed to resolve or if a patient developed jaundice, cholangitis, or a combination of a flu-like syndrome and cholestasis, an ERCP was performed to confirm obstruction of the stent. Subsequent treatment consisted of exchange of the occluded stent by insertion of a polyethylene stent or a self-expandable metal stent.
Stent patency represented the interval between the time of stent insertion and the time of its replacement or the presence of both jaundice and fever at the time of death. Complications of ERCP and sphincterotomy were evaluated according to the criteria of Cotton (13).
Statistical analysis
Patient survival and stent patency were analysed by means of the Kaplan-Meier method and compared using the log-rank test. The Chi-square test was used for comparison of categorical data. All tests were two-tailed and p-values <0.05 were considered statistically significant.

RESULTS
Patient enrolment and characteristics
Between February 1998 and September 1998, 60 consecutive patients were included in the study. Fifty-seven patients had pancreatic cancer and three had ampullary cancer. There were 29 men and 31 women with a median age of 77 (range 43-92 years). Thirty patients were randomised to a TTC stent and thirty to a PE stent. Patient characteristics were comparable between the two groups (Table 1).

Early Results
Stent insertion was successful in all patients. Procedure-related complications occurred in 4 patients: perforation in one (PE), haemorrhage in three (TTC 2, PE 1). All complications were graded as mild. The patient who suffered a perforation (PE) recovered uneventfully after conservative therapy. All three haemorrhages occurred during precut papillotomy and were successfully treated by sclerotherapy without the need for blood transfusion. There was no significant difference in the occurrence of procedure-related complications between the two groups.
Biliary drainage was successful in 53 patients (88%). Seven patients had no decline of bilirubin >20% of the pre-procedure value within one week after stent insertion. In three of these patients a repeat ERCP and a stent exchange (to PE stent) were performed (TTC 3). Two patients died respectively 9 and 13 days after the procedure without intervention (TTC 2). In the remaining two patients jaundice slowly subsided without intervention (TTC 1, PE 1).

Late results
Stent occlusion occurred in 30 patients (50%) (Table 2). An ERCP was performed in 23 patients; the remaining 7 were considered unfit for further treatment. Median stent patency was 102 days (range 4-264, 95% CI 36-168) in the TTC group and 142 days (range 7-277, 95% CI 32-252) in the PE group (Figure 1). There was no significant difference in stent patency between the two groups (p=0.41).
Stent migration, in all cases proximally into the common bile duct, was noted in 4 patients (13%) in the TTC group. In two patients the stent could not be removed after several attempts and a second stent was placed through the stenosis alongside the proximally migrated stent to ensure adequate drainage. In the remaining patients the stent could be removed by a dormia basket after papillotomy and a PE stent was inserted afterwards. In the PE group no stents were found to have migrated. There
was a significant difference in the incidence of stent migration between the two groups \((p=0.038)\).
Median patient survival was 121 days in the TTC group and 105 days in the PE group \((p=0.28)\).

**DISCUSSION**

*In vitro* studies have suggested that both material as well as design may affect stent patency. For example, stents made of Teflon have a lower friction coefficient than other plastics and therefore seem more suited to prevent stent blockage \((6)\). With respect to stent design it has been shown, both *in vitro* and *in vivo*, that conventional polyethylene stents with side holes accumulate significantly more sludge than stents from the same material without side holes \((6;10)\).

Data from clinical studies regarding these issues are not convincing and in fact contradictory. Soehendra and co-workers developed a Teflon stent without side holes, which they refer to as the Teflon Tannenbaum stent. The results from their non-randomised trial indicate a prolonged patency rate \((7)\). From this study design it could not be inferred whether the absence of side holes, the Teflon material or both were responsible for these encouraging initial results. Two other studies looking at each item individually did not provide more insight in this matter. Sung and co-workers compared in a randomised trial a conventional PE stent with side holes to a PE stent without side holes and did not show a difference in patency rate \((14)\). Our group compared a conventional polyethylene stent with side holes to the same design stent made of Teflon material and also did not show any difference in stent patency \((15)\).

Until now three multicenter randomised trials compared the Teflon Tannenbaum stent to a polyethylene stent and none of these studies showed any advantage for the Teflon Tannenbaum stent \((8;9)\)(Table 3).

Abedi and co-workers tested a modified Tannenbaum design stent consisting of a stainless steel mesh between an inner Teflon coating and an outer polyamide layer (TTC stent). Preliminary results from their non-randomised study in 12 patients showed a mean patency was 134 days and no stent occlusion \((11)\). The authors claim that this new stent provides a 20% greater lumen than a comparable size plastic stent. Our group however, determined the internal and external diameter of unused biliary endoprosthesis and could not confirm an increased diameter of the TTC stent \((16)\). Interestingly, in the study of Abedi, the TTC stent migrated proximally in two of twelve patients.

In the present randomised study we could not show any difference in patency rate between the TTC stent and the conventional PE stent. In line with the study of Abedi and co-workers we also observed multiple cases with proximal migration of the TTC stent. In fact, the difference in the incidence of proximal stent migration between both groups (PE 0 versus TTC 4) was statistically significant.

Early biliary stents were equipped with a pigtail at the proximal end to prevent migra-
tion. In order to improve bile flow these stents were replaced by straight Amsterdam type stents with one side hole at both ends in which stent migration is prevented by one side flap, also at both ends. The Tannenbaum stent is designed with four radial side flaps that do not penetrate the lumen of the stent. This results in more floppy side flaps than is the case with conventional cut side flaps, which, according to our results seems unsatisfactory to prevent dislocation. In some centers it is routine practice to perform a papillotomy to facilitate stent placement and this may even further contribute to stent migration.

In the light of these observations, we performed a crude meta-analysis of all six studies performed with Tannenbaum design Teflon stents and conventional PE stent and found a non-significant trend for excess TTC stent migration (p>0.05) (Table 3). It must be noted however, that interpretation of these so-called migrations is difficult because in most studies stent migration is not formally defined and it is not noted whether stents migrated proximally or distally. To make things even more complicated; stent migration may remain asymptomatic if the stenosis is still traversed. It may also be wrongly recorded as stent occlusion if the proximal end of the stent gets impacted in the bile duct wall (proximal migration) or the distal end gets impacted in the duodenal wall (distal migration). Due to the lack of side holes in the TTC stent these conditions mimic stent occlusion but are in fact caused by stent migration. In fact, the difference between stent dislocation and stent obstruction can only be confirmed when the stent lumen is assessed macroscopically or a water immersion test is performed (17). Unfortunately, in most studies, including our own study, this was not done.

In conclusion, this prospective randomised trial did not confirm the expectations of earlier studies regarding improved patency rates of Teflon Tannenbaum stents. These stents seem associated with an excess incidence of proximal stent migration, which prompts for additional design modifications.
### Table 1. Patient characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>TTC stent</th>
<th>PE stent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No included</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Male/Female</td>
<td>15/15</td>
<td>14/16</td>
</tr>
<tr>
<td>Age *</td>
<td>77 (43-93)</td>
<td>78 (61-92)</td>
</tr>
<tr>
<td>Bilirubin **</td>
<td>286 (10-837)</td>
<td>224 (64-624)</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pancreatic cancer</td>
<td>30</td>
<td>27</td>
</tr>
<tr>
<td>Ampullary cancer</td>
<td>0</td>
<td>3</td>
</tr>
</tbody>
</table>

**TTC**: Tannenbaum type stent with a thin stainless steel mesh between an inner Teflon Coating and an outer polyamide layer

**PE**: standard Polyethylene stent

* values are median (range) in years

** values are mean (range) in μmol/l

### Table 2. Results.

<table>
<thead>
<tr>
<th>Complications</th>
<th>TTC stent</th>
<th>PE stent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perforation</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Haemorrhage</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Proximal migration*</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Stent dysfunction</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>ERCP performed</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>no ERCP performed</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Patient survival, days **</td>
<td>121 (9-357)</td>
<td>105 (14-413) [55-155]</td>
</tr>
<tr>
<td>Stent patency, days **</td>
<td>102 (4-264)</td>
<td>142 (7-277) [32-252]</td>
</tr>
</tbody>
</table>

**TTC**: Tannenbaum type stent with a thin stainless steel mesh between an inner Teflon Coating and an outer polyamide layer

**PE**: standard Polyethylene stent

*p=0.038

** values are median (range), [95% confidence interval]
Figure 1. Kaplan-Meier plot of stent patency ($p=0.41$).
Table 3: Review of Tannenbaum Teflon stent studies.

<table>
<thead>
<tr>
<th>Patient Follow-up (days)</th>
<th>Occlusion Rate</th>
<th>Angioplasty/Recanalization</th>
<th>Study Design</th>
<th>Median Teflon Stent Induced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Beek et al. (10)</td>
<td>Non randomized</td>
<td>Single center             Tannenbaum and 12 TC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catelino et al. (9)</td>
<td>Non randomized</td>
<td>Single center             Tannenbaum and 12 TC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>England et al. (8)</td>
<td>Non randomized</td>
<td>Single center             Tannenbaum and 12 TC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terzoli et al. (6)</td>
<td>Non randomized</td>
<td>Single center             Tannenbaum and 12 TC</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 8%                      | 12/27 | Tannenbaum and 12 TC |                |                            |
| 16%                     | 14/27 | Tannenbaum and 12 TC |                |                            |
TANNENBAUM TYPE TEFLOM COATED VERSUS POLYETHYLENE STENTS

REFERENCES


