Clinical Analysis of Pericardial Devascularization by Preserving Vagus Trunks in 42 Patients with Portal Hypertension

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Pericardial devascularization (PD) is less of a burden and provides better bleeding control to patients compared to shunt procedures, and so has been widely used in portal hypertension in China. However, because the vagus trunks are interrupted during surgery, patients easily suffer from postoperative stomach adynamia. Based on our understanding from autopsy of the path of vagus trunks along the distal oesophagus, we designed the operative procedure of PD by preserving vagus trunks (PDPVT) to treat portal hypertension. Between May 1991 and January 2003, patients with portal hypertension were treated surgically using PDPVT ($n=42$), single PD ($n=32$), or PD with pyloroplasty (PD +PP; $n=16$). Operative mortality was 2.4% in the PDPVT group and 6.3% in both the PD and PD +PP groups ($p>0.05$). The postoperative rebleeding rate was 9.5% in the PDPVT group and 12.5% in both the PD and PD +PP groups ($p>0.05$). There were no differences in operative time and estimated blood loss between the three groups ($p>0.05$). The recovery time for gastroenteric function was shorter with PDPVT (mean, 3.5 days) than with PD (mean, 5.7 days) and PD +PP (mean, 4.2 days; $p<0.02$). Incidences of early satiety and enterogastric reflux were significantly lower in the PDPVT group (both 4.8%) than in the PD group (46.9% and 18.8%) and PD +PP group (12.5% and 100%; $p<0.005$). Incidences of retention of gastric juice, diarrhoea and late gallstones were 12.5%, 15.6% and 7.1% respectively, in the PD group, and 12.5%, 18.8% and 6.3% respectively, in the PD +PP group, but none of these were observed in the PDPVT group. Since it preserves vagus trunks, PDPVT can maintain normal stomach dynamics and physiological function of hepatobiliary and gut systems better than PD and PD +PP, thus reducing incidences of postoperative complications. Thus, PDPVT is superior to PD and PD +PP in the treatment of portal hypertension. [Asian J Surg 2004;27(2):108-13]

Introduction

Pericardial devascularization (PD) has been widely used in patients with portal hypertension in China because it is less of a burden and provides better bleeding control compared to shunt procedures. Because the vagus trunk is interrupted during surgery, it is easy for patients to suffer from stomach adynamia, and the incidence of gastric stasis ranges from 14% to 40% postoperatively. In order to prevent such postoperative complications, we have used PD by preserving vagus trunks (PDPVT) to treat 42 patients with portal hypertension since 1991, and compared the results with those of single PD and PD plus pyloroplasty (PD +PP) performed during the same period (May 1991 to January 2003).
**Basic research**

In order to determine the vagus physiological function on the stomach, and especially on the pylorus, we carried out a study in dogs. Sixteen mongrel dogs of both sexes weighing 18 to 20 kg were divided into two equal groups and anaesthetized with intravenous pentothal (25 mg/kg). The peritoneal cavity was entered through the midline, double electrodes were inserted into the pyloric sphincter, and a water bag with a manometric tube was placed in the cavity of the pyloric antrum. The water bag was filled with 10 mL of normal saline and connected to the manometric tube; the electrodes were connected to a two-way physiological recording instrument (Two-channel Physiologic Kymograph; Mianyang Medical Instrument Factory, Mianyang, Sichuan, China) to record the wave pre- and postoperatively (Figure 1).

Pressure changes in the pyloric cavity were caused by contraction due to the action current of the pyloric smooth muscle, which was synchronous with other parts of the stomach and so could represent the whole stomach. We chose the pylorus for the following advantages: the pyloric sphincter is thicker than any other part of the stomach, so it is easy to fix electrodes to it, and the volume of the pyloric cavity is small, with a concentrated pressure suitable for the induction water bag observation.

Eight dogs underwent PDPVT and eight underwent PD. The action current of the sphincter muscle in the PDPVT group was 12 to 25 times as high as that in the PD group (t = 6.9531; p < 0.001) (Table 1). At the end of an action current, a contraction wave came rhythmically; there were no differences in the waves before and after surgery in the PDPVT group (t = 0.8739; p > 0.05). The action current in the PD group was neither obvious nor synchronous with the contraction wave. Spasmodic contraction of the pyloric muscle caused frequent pressure waves to emerge and led to the retention of gastric juices.

In order to maintain normal gastric dynamics, we began to study PDPVT with regard to portal hypertension. We dissected 25 adult human corpses in order to understand the location and route of the anterior and posterior vagus trunks along the distal oesophagus and the proximal stomach. The anterior and posterior oesophageal walls were divided into three equal parts. The anterior vagus trunk was on the right in six cases (24%), in the middle in 15 cases (60%), and on the left in four cases (16%). The posterior vagus trunk was on the right in 20 cases (80%) and in the middle in five cases (20%); in no case was it on the left. The length of the oesophagus from its hiatus to the cardia averaged 2 cm. In the light of these anatomical results, it would seem better to make the incision in the distal oesophagus on the left posterior side, to protect the main trunks of the vagus nerve from injury.

**Patients and methods**

Of the 42 patients with portal hypertension in the PDPVT group, there were 20 men and 22 women, with a mean age of 42.7 years (range, 15–71 years). In the PD group, there were 32 patients, 17 men and 15 women, with a mean age of 38.0 years (range, 5–64 years). In the PD+PP group, there were 16 patients, 7 men and 9 women, with a mean age of 37.4 years (range, 16–61 years). Patients were randomly assigned to a form of surgery, although the PD+PP procedure was not used after 1997. After 1997, patients were randomized by drawing lots for procedures.

**Table 1. Comparison between action current of pyloric smooth muscle and pressure in pyloric cavity (mean ± standard deviation)**

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 8)</th>
<th>PDPVT (n = 8)</th>
<th>PD (n = 8)</th>
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</thead>
<tbody>
<tr>
<td>Action current (mV)</td>
<td>0.916 ± 0.384</td>
<td>0.847 ± 0.360*</td>
<td>0.042 ± 0.041'</td>
</tr>
<tr>
<td>Pressure (kPa)</td>
<td>3.396 ± 0.427</td>
<td>3.371 ± 0.435*</td>
<td>3.538 ± 0.612*</td>
</tr>
</tbody>
</table>

*p > 0.05, †p < 0.001, compared with normal control group.
The main clinical manifestations, including the extent of oesophagogastric varices, history of bleeding and grade of hepatic function, were compared among the three groups (Table 2).

PDPVT operative procedure
The gastrocolic ligament was initially separated and excised from the two distal branches of the right gastro-epiploic vessel along the greater curvature. The spleen was also routinely removed. The vagus branches, lesser omentum and collateral vessels were initially ligated close to the gastric wall using forceps just above the crow’s foot along the lesser curvature. Care was taken to avoid ligating the vagus nerve. The end of the gastric wall was sutured and ligated in case the ligature was exfoliated due to the stomach being drawn and possible gastric peristalsis. When separation along the lesser curvature was 1 cm below the cardia, the incision was directed obliquely to the His angle. Using scissors to open the serous layer and the left lateral peritoneum covering the oesophagus, we separated the muscle layer as closely as possible, preserving both the anterior and posterior trunks of the hepatic and celiac branches of the vagus nerve. The posterior gastric wall was exposed with the coronary vein, including its gastric, oesophageal and high oesophageal branches, and the connecting tissues attached to the posterior oesophageal wall such as the branches of the vagus and relevant vessels. These were dissected up to 7 cm to 8 cm above the cardia. The upper stomach and the distal oesophagus were devascularized and the seromuscular layers of the lesser curvature were closed with interrupted silk sutures (Figure 2).

Eight splenorenal, five portacaval and two splenocaval shunts, and five oesophageal transections, and re-anastomosis with a stapling device were performed in the PD group. Four splenorenal, one portacaval and one superior mesenteric-inferior vena cava shunts were performed in the PD+PP group. All patients in the PDPVT and the PD+PP groups were followed up. Contact was lost with four patients in the PD group. Mean follow-up for the three groups was 57 months (range, 5–120 months).

Statistical analysis
Data are presented as mean ± standard deviation. Differences between groups were analysed with the t test. The Chi-squared test was used for clinical manifestations, morbidity and mortality rates, and the actuarial survival rates. A p value of less than 0.05 was considered to indicate statistical significance.

Results
The mean operative time was 157.0 ± 18.3 minutes in the PD group, 173.8 ± 21.5 minutes in the PDPVT group and 188.8 ± 15.0 minutes in the PD+PP group (p > 0.05). Mean estimated operative blood loss was 1,062.5 ± 175.5 mL during the PD procedure, 1,168.8 ± 167.4 mL during the PDPVT procedure, and 1,156.3 ± 141.3 mL during the PD+PP procedure (p > 0.05). The recovery time for gastroenteric function ranged from 2 to

### Table 2. Comparison of clinical manifestations among groups

<table>
<thead>
<tr>
<th></th>
<th>PDPVT (n = 42)</th>
<th>PD (n = 32)</th>
<th>PD+PP (n = 16)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-hepatic cirrhosis</td>
<td>39 (92.9)</td>
<td>29 (90.6)</td>
<td>16 (100)</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Oesophageal varices*</td>
<td>40 (95.2)</td>
<td>25 (78.1)</td>
<td>12 (75.0)</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>History of bleeding</td>
<td>36 (85.7)</td>
<td>22 (68.8)</td>
<td>10 (62.5)</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Child-Pugh A</td>
<td>24 (57.1)</td>
<td>19 (59.4)</td>
<td>9 (56.3)</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Child-Pugh B</td>
<td>18 (42.9)</td>
<td>13 (40.6)</td>
<td>7 (43.8)</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

* Barium meal examination showed moderate to severe oesophagogastric varices.
6 days (mean, 3.5 days) in the PDPVT group, but took from 3 to 28 days (mean, 5.7 days) in the PD group, and from 3 to 16 days (mean, 4.2 days) in the PD+PP group. The differences between the three groups were significant (t = 2.524; p < 0.02).

Postoperative complications are shown in Table 3. One patient in the PDPVT group died of a subphrenic abscess. In the PD group, one patient died of pulmonary embolism and another died of hepatic coma after portacaval shunt. One patient in the PD+PP group died of hepatic and renal failure. The incidences of gallstones in the PD and the PD+PP groups were 7.1% and 6.3%, respectively, whereas no patients in the PDPVT group developed gallstones in the follow-up period.

The mortality rate was 7.1% in the PDPVT group, 17.9% in the PD group, and 12.5% in the PD+PP group. There was a significant difference among the groups (χ² = 0.048 and χ² = 0.191; p > 0.05). The 5- and 8-year actuarial survival rates were 92.9% (39/42) and 88.1% (37/42), respectively, in the PDPVT group, 89.3% (25/28) and 82.1% (23/28) in the PD group, and 93.8% (15/16) and 87.5% (14/16) in the PD+PP group. There were no significant differences among the three groups (χ² = 0.004 and χ² = 0.287; p > 0.05).

Discussion

There are two kinds of vagus postganglionic neurofibres: excitatory and inhibitory. The former accelerate transduction of the basic electrotonus (slow wave) from the upper part of the greater curvature, producing the action current and causing rhythmic contraction of the stomach. The latter cause gastric diastolization. Both cooperate to cause rhythmic contraction and relaxation.3,4 Our experiment in dogs showed that the action current after vagotomy was 12 to 25 times lower than before vagotomy, so gastric contraction lacked dynamism. Although the submucosal plexus, stimulated by food, can also cause the stomach to contract, this contraction is frequent and spastic and easily leads to gastric stasis and satiety after a meal, as well as other chronic undesirable sequelae.

The recovery time for gastrointestinal function is an important index in judging postoperative gastrointestinal dynamics. Gastroenteric function is flatulence and defeation from the anus, elimination of abdominal distension and return to normal bowel sounds. We calculated the number of days from surgery to extraction of the gastric canal. Half of the patients undergoing PD recovered their gastrointestinal function more than 5 days after surgery (mean, 5.7 days). We were unable to extract one patient's gastric canal until the 28th day after the operation. Nearly 91% of patients undergoing PDPVT recovered their gastrointestinal function within 4 days after surgery (mean, 3.5 days). Thus, the PDPVT group had a shorter gastrointestinal recovery time (p < 0.02). The early satiety rate was significantly higher in the PD group than in the PDPVT group (p < 0.005).

The incidences of gastric stasis, nausea and vomiting, and diarrhoea were also significantly higher in the PD group, while none were observed in the PDPVT group. Because the peristaltic pacemaker, situated above the greater curvature, is incised in the PD procedure,5 there is less gastric peristalsis after PD.6 Gallstones were found in patients undergoing PD and PD+PP, whereas no patients in the PDPVT group developed gallstones in the follow-up period. As motor innervation to the antrum, pylorus, liver and abdominal cavity were preserved in patients undergoing PDPVT, these patients maintained not only their gastric evacuation function, but also their hepatic and intestinal physiological functions.

The incidences of early satiety after meals and gastric stasis

<table>
<thead>
<tr>
<th>Table 3. Postoperative complications in the three groups</th>
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<tbody>
<tr>
<td>PDPVT (n = 42)</td>
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<td>----------------</td>
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<tr>
<td>Early satiety</td>
</tr>
<tr>
<td>Nausea/vomiting</td>
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<tr>
<td>Gastric stasis</td>
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<tr>
<td>Enterogastric reflux</td>
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<tr>
<td>Diarrhoea</td>
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<tr>
<td>Rebleeding</td>
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<tr>
<td>Others*</td>
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<tr>
<td>Operative death</td>
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*Including hepatic coma, pulmonary embolism, portal thrombosis, subphrenic abscess and hepatorenal syndrome.
were both 12.5% in the PD +PP group, but the incidence of enterogastric reflux was the highest among the three groups. Nine of the 16 patients (56.3%) suffered burning epigastric pain and chronic nausea. Although the PP procedure enhances gastric emptying, it can also cause reflux from the duodenum into the stomach, leading to bile reflux gastritis and even dumping for individual patients. However, the incidence of dumping is greatly reduced with a proximal gastric vagotomy. The incidence of diarrhoea was higher in patients undergoing the PD +PP procedure. This was obviously related to transection of the celiac division of the vagus nerve, causing acceleration of the emptying of the stomach and the rapid passage of unconjugated bile salts from the denervated biliary tree into the colon, where they could stimulate secretion. PP is unnecessary in patients undergoing PD PVT because the vagus trunks and pyloric innervation are preserved in PD PVT, so the normal physiological function of the pylorus is retained postoperatively. We have not used the PD +PP procedure since 1997 because of these disadvantages.

The non-shunt devascularization procedure has potential advantages including preservation of portal perfusion and hepatic function. This procedure plays an important role in the acute control of the bleeding episode and may represent definitive management in patients who are not shunt candidates. However, we sometimes used a combined procedure (shunt plus non-shunt), especially when the free portal pressure was greater than 34 cmH₂O or the diameter of the splenic vein was more than 10 mm with no inflammation around it. The combined procedure can remove the disadvantages of the PD and shunt procedures, lower the portal pressure, preserve portal blood flow, prevent recurrence of newly collateral circulation, and improve the long-term effect.

In each of the three groups, the free portal pressure was much lower after surgery than before (p <0.05), mainly because of the removal of the spleen. The long-term rebleeding rates were similar to those reported by Williams and Westaby. The mortality rates due to rebleeding were 7.1%, 17.9%, and 12.5%, respectively, with no significant differences between the three groups (p >0.05). After bleeding was controlled by successful surgery, most patients did not progress to hepatic failure and they did well postoperatively, with a good quality of life. This has also been observed by other authors.

In our autopsy study, we found that if the anterior and posterior oesophageal walls, respectively, were divided into three equal parts, 84% of the anterior trunk of the vagus nerve would lie in the right or median area, all of the posterior trunk would lie in the right or median area, and the hepatic branch divided from the anterior trunk would, on average, be 2.6 cm lower and the celiac branch would, on average, be 3.1 cm lower than the oesophageal hiatus. Thus, a curve of incision could be outlined from below the cardia to the His angle and then to the left lateral oesophagus. The lesser curvature should be freed from 1 cm below the cardia and the serous layer should be incised from this point to the His angle, and then the serous layer of the left lateral oesophagus could be incised up to the oesophageal hiatus. Since only 16% of the anterior trunk of the vagus nerve passes through the left part and it is close to the boundary between the left and median parts, and the left part of the posterior oesophagus is an area through which no posterior trunk passes, the left lateral oesophagus is a safe area for avoiding injury to the vagus nerve. The total measurement from 1 cm below the cardia along the lesser curvature to the oesophageal hiatus is 4 cm, including the 2 cm from the cardia to the oesophageal hiatus, 1 cm from the incisura angularis along the lesser curvature vertically to the His angle opposite the lesser curvature, and 1 cm from the cardia to the site of the incision. However, the celiac division of the vagus nerve, as the farthest one, is only 3.1 cm from the oesophageal hiatus. Therefore, surgery performed along the designated curve of the incision can protect not only the anterior and posterior trunks, but also the hepatic and celiac divisions of the vagus nerve from injury. It should be noted that if a gross and hard core on the surface of the oesophageal wall can be felt, then care must be taken to protect it, as it is most likely a main trunk of the vagus nerve.

During surgery, the principle of complete and thorough portoazygous disconnection, especially to include the high oesophageal and the ectopic high oesophageal branches of the coronary vein, should be followed. The high oesophageal vein originates from the convex oesophageal division of the coronary vein and travels upwards along the right posterior oesophagus and enters the muscular layer of the oesophageal wall 3 cm to 4 cm above the cardia, with a diameter of 0.6 cm to 1 cm. However, the ectopic high oesophageal branch, usually running parallel to the high oesophageal branch, originates from the main trunk of the coronary vein (though occasionally from the left trunk of the portal vein), and enters the oesophageal wall nearly 5 cm above the cardia. Hence, devascularization of the distal oesophagus should not be less than 6 cm. It is easy to draw the oesophagus downwards longitudinally and free 6 cm to 8 cm of its distal part because of the excision of the anterior and posterior main trunks of the vagus nerve in the PD procedure. If the vagus trunks are
not excised, it is difficult to draw the oesophagus so far downwards longitudinally. By tying a gauze ribbon round the oesophagus, it can be drawn to the left, and the vagus trunks and collateral tissues to the right using a deep retractor, the distal 7 cm to 8 cm of the oesophagus can easily be freed in order to achieve the aim of extensive devascularization.

References