Reduction in Bleeding after Heart-Lung Transplantation*

The Importance of Posterior Mediastinal Hemostasis

Richard J. Novick, M.D., MSc., F.C.C.P.; Alan H. Menkis, M.D., F.C.C.P.; F. Neil McKenzie, M.D., F.C.C.P.; Ken R. Reid, M.D.; Peter W. Pflugfelder, M.D.; William J. Kostuk, M.D.; and Dildar Ahmad, M.D., F.C.C.P.

To reduce perioperative hemorrhage following heart-lung transplantation, several technical modifications were introduced in June 1988 to secure better posterior mediastinal hemostasis. The intraoperative and postoperative use of blood and blood products, as well as the chest tube drainage in the first 24 hours postoperatively, were compared in the seven patients operated on since June 1988 with the nine patients operated on before that date. Significant (p<0.05) reductions were demonstrated in the intraoperative and postoperative transfusion of packed cells, in the postoperative administration of fresh frozen plasma, and in the chest tube drainage within the first 24 hours postoperatively. The one-month and total hospital mortality rates were 6 percent and 12.5 percent, respectively. It is concluded that newer techniques to obtain optimal posterior mediastinal hemostasis have significantly reduced blood loss following heart-lung transplantation in our experience and have contributed to our excellent early postoperative results.

(Chest 1990; 98:1383-87)

HLT = heart-lung transplantation

Patients and Methods

The 16 patients undergoing HLT all had advanced cardiorespiratory failure and were oxygen dependent. The recipients were 12 female and four male subjects, ranging in age from 9 to 50 years (mean, 31±3 years). The preoperative diagnoses of the HLT recipients are shown in Table 1. Only one patient, operated on in November 1989, had undergone a previous thoracotomy; none had had a previous sternotomy. The technique of the donor heart-lung procurement was identical to that described by Jamieson et al, except that an iso-oncotic 4°C solution of 5 percent albumin and Ringer's lactate solution was administered as a pulmonary flush, instead of modified Collins solution. After the administration of cardioplegia and the pulmonary flush solution, the heart-lung block was excised, dividing the trachea at least five rings above the carina. The organs were then placed in a basin containing sterile saline solution at 4 to 8°C and were transported to the recipient operating room.

The recipient operation was performed in a manner similar to that described in the above-mentioned report. Accessible pleural adhesions were divided with the electrocautery prior to heparinization and cannulation for cardiopulmonary bypass. After separate excision of the heart and both lungs, and removal of the left atrial...

Table 1 — Preoperative Diagnoses of Heart-Lung Transplant Recipients

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No.</th>
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<tbody>
<tr>
<td>Primary pulmonary hypertension</td>
<td>4</td>
</tr>
<tr>
<td>Eisenmenger's syndrome</td>
<td>2</td>
</tr>
<tr>
<td>Fibrosing alveolitis</td>
<td>1</td>
</tr>
<tr>
<td>Pulmonary thromboemboli</td>
<td>1</td>
</tr>
<tr>
<td>Immotile cilia syndrome</td>
<td>1</td>
</tr>
<tr>
<td>Group B (June 1988–November 1989)</td>
<td></td>
</tr>
<tr>
<td>Primary pulmonary hypertension</td>
<td>6</td>
</tr>
<tr>
<td>Fibrosing alveolitis, right ventricular infarct</td>
<td>1</td>
</tr>
</tbody>
</table>

*From the Divisions of Cardiovascular-Thoracic Surgery, Cardiology, and Respiratory Medicine, University Hospital, London, Ontario, Canada. Manuscript received February 20; revision accepted June 6.
Reprint requests: Dr. Novick, Division of Chest Surgery, PO Box 5339, University Hospital, London, Ontario, Canada N6A 5A5.

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pulmonary artery, and main bronchial remnants, hemostasis was secured in the posterior mediastinum. Prior to June 1988, in nine patients (group A), this was accomplished by the use of vascular clips and electrocautery, with care taken not to traumatize the vagus nerves. After June 1988, in the last seven transplants (group B), several technical modifications were implemented. First, as much posterior pericardium as possible was left in the recipient. Second, the mediastinal parietal pleura was sutured to the lateral edge of the pericardium on each side using a running 4-0 polypropylene suture (Fig 1). Third, in addition to the use of electrocautery and vascular clips in the superior aspect of the posterior mediastinum, further hemostasis was secured by taking large bites of the posterior mediastinal tissues using a running 3-0 polydioxanone suture while performing the posterior wall of the tracheal anastomosis. The anterior wall of the tracheal anastomosis was performed using interrupted 3-0 polydioxanone sutures. After completion of the tracheal anastomosis, the right atrial anastomosis was performed using running 3-0 polypropylene, incorporating the entire intertrabecular septum, including any left atrial remnants, in the suture line. Finally, the aortic anastomosis was completed using continuous 4-0 polypropylene. Following de-airing of the heart, the vent site in the left atrial appendage and the hole for the pulmonary flush catheter in the pulmonary artery were closed. After the successful discontinuation of cardiopulmonary bypass, protamine sulfate was administered in a dose necessary to return the activated clotting time to its prebypass control. Blood and blood products were administered to maintain a hemoglobin greater than 90 g/L. Angled tubes were inserted into both pleural spaces, and angled and straight mediastinal tubes were also placed.

After surgery, the patients were monitored in the intensive care unit, and then transferred to a specialized multiorgan transplant unit within 24 hours of extubation. Packed cells were administered to maintain a hemoglobin greater than 90 g/L, and, if the total chest tube drainage was in excess of 150 mL/h, fresh frozen plasma and platelets were infused to normalize the coagulation status. Pleural and mediastinal tubes were removed when they were no longer draining greater than 10 mL per tube per hour over a 12-hour period. Further details of the postoperative care, immunosuppression, and serial bronchoscopic follow-up of our patients are described elsewhere.16

Statistical Analysis

Numeric data are expressed as mean ± SEM. Actuarial survival figures and their SEs were calculated according to the method of Cutler and Ederer.3 The statistical significance of differences between the two groups of patients was determined by the two-tailed t test.

FIGURE 1a, (upper). Appearance of the chest following removal of the recipient's heart and both lungs. As much posterior pericardium as possible is left in situ. Both main bronchi will be subsequently excised and the trachea trimmed to one ring above the carina. FIGURE 1b, (lower) Using a running 4-0 polypropylene suture, the posterior mediastinal pleura is sutured to the posterior pericardium from the diaphragmatic surface to the cephalad aspect of the pericardial reflection on each side. Subsequently, large bites of the posterior mediastinal tissues will be incorporated in the posterior aspect of the tracheal anastomosis to obtain better hemostasis in that region.
Table 2—Preoperative Patient Data*

<table>
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<tbody>
<tr>
<td>Age, yr</td>
<td>32 ± 3</td>
<td>30 ± 5</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>59 ± 7</td>
<td>55 ± 6</td>
</tr>
<tr>
<td>Hemoglobin, g/L</td>
<td>155 ± 9</td>
<td>157 ± 8</td>
</tr>
<tr>
<td>Prothrombin time, s</td>
<td>14 ± 1.2</td>
<td>13 ± 0.7</td>
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<tr>
<td>Partial thromboplastin time, s</td>
<td>36 ± 2.4</td>
<td>33 ± 1.6</td>
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*± = standard error of the mean. NS = p > 0.05 between adjacent variables.

RESULTS

Of the 16 HLT recipients, one died within the first 30 days postoperatively, due to respiratory failure at 36 hours. Another patient developed of a false aneurysm at the aortic anastomosis as well as cytomegalovirus pneumonia, and died five weeks postoperatively. The 30-day operative and total hospital mortality rates were, therefore, 6 percent and 12.5 percent, respectively. Eleven of the HLT recipients are still living, and our current one- and two-year actuarial survival rates are 87 ± 8 percent and 69 ± 13 percent, respectively.

There were no significant differences in preoperative patient variables, including hemoglobin, prothrombin time, and partial thromboplastin time, between the group A and group B patients (Table 2). In addition, there were no significant differences in preoperative renal and hepatic function between the two groups. The warm ischemic times of the heart-lung graft were similar in groups A and B, but because of the more recent practice of distant donor procurement, the cold and total ischemic times were significantly longer in group B (Table 3). The time on cardiopulmonary bypass was slightly more prolonged in group A patients, reflecting the additional effort required to obtain posterior mediastinal hemostasis prior to the discontinuation of cardiopulmonary bypass.

The intraoperative and postoperative transfusion of blood and blood products was often considerable and highly variable in group A patients but was markedly reduced in the seven most recently operated-on patients (Table 4). The combined mediastinal and chest tube drainage at 24 hours postoperatively was significantly less in group B, although the difference in reexploration rates for hemorrhage between the two groups did not reach statistical significance (Table 5). In our last three HLT recipients, two did not require any intraoperative transfusions, and the third received only a single unit of packed cells during the procedure.

Discussion

Heart-lung transplantation is nearing the end of its first decade of clinical application. Because the number of satisfactory heart-lung grafts is limited, only a few centers in North America have acquired a significant experience and hence technical facility with the procedure. Intraoperative hemorrhage and postoperative hemorrhage from pleural adhesions and the posterior mediastinum have been problematic in the early experience with HLT, and with infection have been a major cause of morbidity and mortality postoperatively.

Several reports emphasize the importance of proper recipient selection in improving the results of HLT. In the early Pittsburgh experience, no patient with a previous sternotomy survived, and those who had undergone previous thoracotomy had

Table 3—Intraoperative Data*

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<tbody>
<tr>
<td>Cold ischemic time, min</td>
<td>40 ± 8</td>
<td>X 93 ± 20</td>
</tr>
<tr>
<td>Total ischemic time, min</td>
<td>101 ± 11</td>
<td>X 153 ± 15</td>
</tr>
<tr>
<td>Pump time, min</td>
<td>248 ± 15</td>
<td>X 201 ± 11</td>
</tr>
</tbody>
</table>

*± = standard error of the mean. X = p ≤ 0.05 between adjacent variables.

Table 4—Units of Packed Cells, Fresh Frozen Plasma (FFP), and Platelets (PLTS) Transfused Intraoperatively and Postoperatively*

<table>
<thead>
<tr>
<th></th>
<th>Intraoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Packed Cells</td>
<td>FFP PLTS</td>
</tr>
<tr>
<td>Group A (May 1983-June 1988)</td>
<td>X NS</td>
<td>X</td>
</tr>
<tr>
<td>Group B (June 1988-November 1989)</td>
<td>1.7 ± 0.6</td>
<td>5.6 ± 1.3</td>
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</tbody>
</table>

*± = standard error of the mean. NS = p > 0.05 between adjacent variables. X = p ≤ 0.05 between adjacent variables.

Table 5—Mediastinal and Pleural Tube Drainage at 24 Hours and the Reoperation Rate for Postoperative Hemorrhage*

<table>
<thead>
<tr>
<th></th>
<th>Chest Tube Drainage at 24 Hours, L</th>
<th>Reoperation for Bleeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A (May 1983-June 1988)</td>
<td>4.3 ± 1.4</td>
<td>3/9</td>
</tr>
<tr>
<td>Group B (June 1988-November 1989)</td>
<td>1.4 ± 0.3</td>
<td>0/7</td>
</tr>
</tbody>
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*± = standard error of the mean. NS = p > 0.05 between adjacent variables. X = p ≤ 0.05 between adjacent variables.
development of postoperative hemorrhage from pleural and mediastinal adhesions. In the Stanford experience, as well, the highest risk of operative mortality occurred in patients with a previous thoracic operation, pleural adhesions, or impaired hepatic function. These factors were strongly correlated with increased perioperative hemorrhage and poor postoperative allograft function due to multiple transfusions. Like the Stanford group, we no longer consider a previous thoracotomy to be a contraindication for HLT, but we review these patients carefully on a case-by-case basis. Our most recent HLT recipient had undergone a previous left thoracotomy and had minimal blood loss perioperatively. Although increasing operative experience in HLT may play a role in improved results in our group B patients, this series represents the experience of several surgeons, each of whom noted a marked reduction in perioperative hemorrhage when the above-described techniques for the reduction of mediastinal bleeding were adopted. Similarly, although patients with Eisenmenger's syndrome may be considered to be at higher risk for hemorrhage due to more prominent posterior mediastinal collaterals, the two patients with this condition in our series had a mean perioperative blood loss and transfusion requirement that was not significantly different from others in group A.

A description of the standard technique of HLT mentions the importance of securing the posterior mediastinal vessels with clips during resection of the recipient's heart and lungs. In addition, the importance of including the entire interatrial septum, including all left atrial remnants, in the right atrial suture line has been emphasized. The Papworth group reinforced the tracheal anastomosis with remnants of the recipient's pulmonary artery in their early experience; currently, as is our practice, they incorporate large bites of the posterior mediastinal tissue in the posterior aspect of the tracheal anastomosis to minimize the possibility of an air leak and to secure better hemostasis in the superior aspect of the posterior mediastinum.

The technique of HLT has been modified by a number of surgeons to diminish the risk of uncontrollable perioperative hemorrhage. In a retrospective case report, Losman advocated leaving the recipient pulmonary artery bifurcation and posterior wall of the left atrium in place and oversewing the orifices of the pulmonary veins. In addition, he referred to the practice of other surgeons in leaving the posterior wall of the tracheal carina and main bronchi in situ. A more innovative approach to minimizing technical complications following HLT has been reported by Vouhe and Dartevelle in 1989. The authors emphasized the importance of a limited dissection of the posterior mediastinum, exposing only the distal trachea and both bronchi. They performed extracardial pneumonectomies and used surgical stapling as much as possible in dividing the left atrial wall and in creating appropriate-sized passages for the donor lungs. They made a routine practice of leaving the posterior wall of the left atrium, the pulmonary artery bifurcation, and the transpericardial aspect of the pulmonary pedicles in situ. Prior to implantation of the donor heart-lung graft, fibrin glue was placed over the posterior mediastinum to achieve optimal hemostasis. Using this approach in 21 patients, the authors recorded a mean blood loss during the first 24 postoperative hours of 800 ± 350 ml. No patient in their experience or in our most recently operated-on group required reoperation for excessive postoperative hemorrhage.

In summary, bleeding has been a major complication of HLT because of the presence of large posterior mediastinal collaterals, coagulopathy from hepatic congestion due to right-sided heart failure, adhesions from previous thoracic operations, and the long cardiopulmonary bypass times that are required. The techniques that we have adopted should decrease the risk of hemorrhagic complications and the risks associated with multiple transfusions after HLT, and thus improve the early outcome after this procedure.

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REFERENCES

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Radiology Courses

The Department of Radiology, University of California San Diego School of Medicine, will present the following postgraduate courses:

Intraluminal Ultrasound, February 6, Le Meridien Hotel, Coronary (San Diego); Basic Introduction to Doppler Principles, February 6, Le Meridien Hotel, Coronado (San Diego); Duplex Imaging Tutorial Conference and Exhibit, February 7-9.

For information, contact Ryals and Associates, PO Box 1925, Roswell, Georgia 30077-1925 (404:641-9773).

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