Surgical Techniques to Reduce Blood Loss and Transfusion Need

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Multiple approaches are available to the surgeon who wishes to reduce patient exposure to the risks of allogeneic blood transfusion. These range from transfusion of the patient's own blood through red cell salvage and reinfusion to the use of drugs such as iron and erythropoietin to restore red cell mass. Transfusion need in surgery is clearly tied to blood loss; it follows that reduction of operative blood loss should minimize the need for transfusion. All surgeons are taught according to Halstedian principles of gentle tissue handling and anatomic dissection, techniques designed in part to reduce intraoperative bleeding. Our increased knowledge about the risks of allogeneic blood has prompted many surgeons to analyze and to revise standard approaches to surgical procedures and/or to develop innovative techniques in an attempt to reduce or eliminate blood loss and transfusion. This brief report will focus on such recent efforts.

BLOOD LOSS

Certain types of surgery are associated with blood loss that frequently leads to the need for transfusion. These include hepatic, orthopaedic, and vascular operations. Hepatic surgery, whether resection for cancer or transplantation, frequently leads to blood transfusion and, consequently, increased morbidity. The negative impact of blood loss during hepatic surgery is demonstrated by two large-scale retrospective studies. Nagasue et al. analyzed 229 patients operated on for primary hepatocellular cancer over an 11-year period. Operative death was associated with Child's class, bromosulphalein (BSP) test, and the amount of intraoperative blood loss.[1] Elias et al. reported on their series of 279 patients treated with hepatectomy for cancer over eight years. Forty-six patients underwent repeat operations. Intraoperative blood loss greater than 1500 mL in this subgroup was significantly related to a higher rate of postoperative complications.[2]

PREOPERATIVE MEASURES

Preoperative correction of coagulation abnormalities is helpful in reducing

blood loss during surgery. Matsumata and colleagues performed a multivariate analysis of 131 patients who had undergone hepatic surgery to determine factors predictive of blood transfusion. Aside from intraoperative blood loss, preoperative body weight and preoperative prothrombin time were the only two predictors. The authors recommend correction of prothrombin time whenever possible to reduce the need for transfusion during hepatic surgery.[3] The type of lesion leading to hepatic resection may have an influence on the amount of intraoperative blood loss. Fan et al. found that attempts to isolate inflow and outflow during hepatic resections in 63 patients with hepatobiliary lithiasis were frustrated in 52% because of extensive scarring and inflammatory fibrosis.[4]

Technical factors and operative approach have a critical effect on hepatic blood loss. Many authors have reported on a variety of vascular isolation techniques to reduce blood loss during hepatic surgery.[5-9] Experience with these techniques can produce excellent results. Jamieson and colleagues at the Center for Digestive Diseases at the Hôpital Pontchaillou in Rennes, France, reviewed blood loss and transfusion rates in 75 patients who underwent liver resections for both benign (N=26) or malignant (N=49) disease.[10] Operations ranged from wedge resection (N=5) through segmentectomy (N=49) to right or left hepatectomy (N=21). Blood loss ranged from 0 to 15 units, and 64% of patients did not need transfusion. Of interest is the fact the the mean length of hospital stay was five days shorter in the nontransfused group. The authors conclude that major liver surgery can be done successfully without blood transfusion in the majority of patients. Their data also suggest that this type of surgery may be more cost-effective when done without transfusion. In a similar review, the same authors report their experience with 49 patients who underwent resection of one or more segments of the liver for either benign or malignant disease. Transfusion requirement ranged from 0 to 15 units, with 63% of patients avoiding allogeneic blood transfusion.[11]

Makuuchi et al. at the National Cancer Center Hospital of Japan in Tokyo report an extensive experience with 362 patients who underwent hepatic resections for hepatocellular carcinoma.[12] Over a 16-year period, this experienced team of surgeons gradually reduced intraoperative blood loss and transfusion rates by the introduction of selective vascular occlusion techniques and the Pringle maneuver. By the last year of the study, 87% of patients were discharged without the need for blood transfusion. Not surprisingly, both operative and overall mortality rates decreased in parallel with transfusion rates. The authors also have compared extrahepatic division of the right hepatic vein in 87 patients who underwent liver resections to an intraparenchymal approach in 32 similar patients.[13] Bleeding complications and overall blood loss were significantly higher when the intraparenchymal approach was used, with massive bleeding occurring in 13% versus 6% of extrahepatic dissections. Mean intraoperative blood loss was 3800 mL for the former compared to 1800 mL for the latter. The extrahepatic approach was technically possible in 89% of patients. In a recent review, this experienced group has summarized requirements for safe hepatic resection. Approaches to minimizing blood loss include the use of vascular isolation and occlusion, the Pringle maneuver, and fibrin sealant application to the cut liver surface.[14]

HEPATIC SURGERY

Two reports of the use of normothermic ischemia during hepatic surgery produced by temporary occlusion of vascular inflow discuss the use of this technique in reducing intraoperative blood loss and transfusion need.[15,16] Hannoun et al. describe 18 patients in whom normothermic ischemia of greater than one hour was tolerated with a mean transfusion rate of 5.3 units of blood.[15] They do not show a specific effect on blood loss but document the ability to employ vascular occlusion safely for prolonged periods of time. Kim et al. did a similar analysis of 47 patients who underwent hepatic resection, dividing them into two groups based on the length of time of vascular occlusion–Group 1: 50-75 min; Group 2: 30-42 min.[16] Mean operative blood loss in each group was significantly less when compared to similar patients treated with conventional techniques (Group 3) and no normothermic ischemia (Group 1: 819 mL; Group 2: 1523 mL; Group 3: 1652 mL; difference between Group 1 or 2 and Group 3 $p<0.05$). This same group has also reported that in situ and surface cooling of the liver during prolonged vascular occlusion reduces blood loss when compared to conventional techniques.[17]

Similar results can be obtained for liver transplantation. Deakin et al. analyzed both patient and technical factors in a group of 300 adult liver transplant patients treated over eight years in an attempt to identify those factors associated with increased blood loss.[18] Among patient factors, only blood urea and platelet count were found to be independent predictors of increased blood loss. Technical factors were more important as shown by the reduction of intraoperative blood transfusion over eight years from 23.5 median units of blood for the first 50 patients to 8 units for the most recent 50. These results were attained as the transplant team gained experience with the use of venovenous bypass and the argon beam coagulator. Bilik et al. compared the use of standard, orthotopic liver transplantation (OLT) to reduced-size liver transplantation (RLST) in pediatric patients with hepatic failure.[19] RLST was devised to help improve the chances of these patients who had long waiting periods for a compatibly sized donor organ. RLST can be done successfully but at the expense of significantly higher intraoperative and postoperative blood loss and transfusion rates. RLST patients received a mean of 515.7 ± 490.9 mL of blood products during surgery compared to only 177.3 ± 278.3 mL for the OLT group.

New methods of localizing and dissecting hepatic tissues have had some success in decreasing blood loss. Baer et al. studied the value of a water jet dissector in reducing blood loss and subsequent transfusion need in 67 patients who underwent major liver resection.[20] Fifty-one patients (76%) were treated using the tissue fracture technique and results were compared to 16 (24%) in whom dissection was done with the water jet. Both blood loss (1386 mL water jet versus 2450 mL tissue fracture) and transfusion requirements (mean 2 units water jet versus 5.2 units tissue fracture) were less in the water jet group, but only the amount of blood transfused was significantly different ($p=.023$). Wu et al. found the use of

intraoperative ultrasonography and intermittent hepatic inflow vascular occlusion led to increased resectability rates and both decreased blood loss and transfusion rates compared to patients treated without these techniques.[21]

Two separate studies from Asia have reported on the usefulness of hepatic dissection using microwave tissue coagulation in reducing blood loss. Zhou et al. report on the effectiveness of microwave dissecting via a monopolar electrode in 50 patients who underwent hepatic surgery for hepatocellular cancer.[22] Blood loss and transfusion need were both reduced in these patients when compared to a similar group of 46 patients who underwent surgery using conventional techniques. Blood loss averaged 215 ± 189 mL using microwave dissection for hepatectomy compared to 652 ± 1008 mL in conventional hepatectomy. It was found that 39.1% of the former group avoided allogeneic transfusion. Lau et al. studied 20 consecutive hepatic resections performed with microwave technique.[23] Mean blood loss was 1132 mL when one patient with an hepatic vein injury was excluded. Five patients (20%) avoided allogeneic blood transfusion.

ORTHOPAEDIC SURGERY

Joint repair and replacement procedures frequently lead to transfusion. Arthroscopic repair, when feasible, results in significantly less blood loss. Green et al. used arthroscopic repair of anterior shoulder dislocations in 20 consecutive patients, resulting in a tenfold decrease in operative blood loss compared to open technique used in 18 others.[24] Modifications of total knee arthroplasty to close the surgically created defect reduces perioperative blood loss. Raut et al. compared 80 patients who underwent press-fit condylar knee arthroplasty, randomizing 40 to closure of the femoral defect with cement to another 40 in whom the defect was left open.[25] Total postoperative blood loss in the cement closure group was 1215 mL compared to 1536 mL in the open-defect group, a difference of 321 mL (approximately one unit of blood).

Operative approach also has an effect on total blood loss. Keene et al. prospectively studied 531 patients with displaced subcapital femoral fractures, randomizing patients to either an anterolateral or a posterolateral approach.[26] The latter resulted in less blood loss and decreased operative time. Staging of knee arthroplasty reduces allogeneic transfusion need but at the expense of increased hospital length of stay and cost. Jankiewicz et al. retrospectively studied the outcomes in 155 bilateral total knee arthroplasty patients, 99 done as simultaneous and 56 as staged procedures.[27] Both perioperative blood loss and transfusion requirements were higher in the simultaneous group, with 60% needing allogeneic transfusion.

Simple measures may have a dramatic impact on blood loss. Levy and Marmar found the use of cold compression following total knee arthroplasty significantly reduced blood loss when compared to a control group of patients. Total blood loss with compression was 1298 mL compared to 1908 mL in the control group, a difference of 610 mL.[28] Tourniquet release for hemostasis was not an effective means of reducing blood loss following primary total knee arthroplasty in 100 consecutive patients studied by Burkart et al.[29]

VASCULAR SURGERY

Major vascular operations are associated with both large-scale and rapid hemorrhage. Bleeding from esophageal varices can be particularly lethal. The use of transjugular intrahepatic portosystemic shunt (TIPS) in the treatment of variceal hemorrhage has been reviewed recently by McCormick et al.[30] The authors note that the shunt can be inserted successfully in 90% of patients and that TIPS can reduce blood transfusion requirements in bleeding patients. Questions remain concerning the risks and long-term patency of TIPS as a primary treatment for variceal bleeding. Further controlled, randomized trials of the use of TIPS are needed before its widespread use can be recommended. The mortality from variceal bleeding remains high in spite of aggressive medical and interventional therapy. Orloff's extensive experience in treating patients with variceal bleeding points out that success may be obtained not just by modifying operative technique but by moving quickly to the operating room to prevent further hemorrhage.[31] Orloff et al. report on their success with emergency portocaval shunting in a group of unselected cirrhotic patients, treated and followed over a period of 10 years. Patients were prospectively randomized after initial medical therapy into two treatment groups, one that continued with medical treatment followed by interval shunt and the second that underwent emergency portocaval shunting within eight hours. Bleeding was controlled completely in all the emergency shunt patients, but 55% of the medically treated patients had recurrent or persistent hemorrhage. Total blood transfusion requirements in the emergency shunt group were significantly less than in the comparison group: 7.1 ± 2.6 units versus 21.4 ± 2.6 units. Eighty-one percent of emergency shunt patients were discharged compared to only 45% of those treated with initial medical therapy, demonstrating the effectiveness of this approach.

The 1990s have seen the introduction of intraluminal stents and grafts in the treatment of large vessel disease, especially the abdominal aortic aneurysm. Two groups have reported their early clinical experience with the use of endoluminal techniques to place grafts and stent-graft devices, showing that major abdominal aortic surgical repair can be accomplished while reducing blood loss.[32,33] These techniques, although in their infancy and in need of further clinical trials, hold great promise for decreasing the need for blood transfusion in vascular surgery.

Direct treatment of the aortic wall may facilitate surgical repair while reducing transfusion need. Chen and associates have reported on the usefulness of direct application of a 25% glutaraldehyde solution to the aortic wall in five cases of aortic dissection.[34] This approach strengthened the fragile aortic wall and helped prevent catastrophic bleeding caused by further perioperative aortic disruption.

COAGULOPATHY

Bleeding caused by trauma and persistent operative bleeding in the coagulopathic patient may be difficult to control. Packing of stellate hepatic lacerations allows the trauma surgeon a means of obtaining pressure control of bleeding and also provides time to correct coagulopathies caused by factor depletion and hypothermia. Unfortunately, bleeding may recur when these same packs, now adherent to the liver surface, are removed at a subsequent

laparotomy. McHenry et al. have described a method of packing using an interposed plastic sterile drape that addresses this problem.[35] They pack the liver laceration with an omental pedicle, followed by a sterile drape. Gauze packs are placed over the drape to provide compression. Because later removal is facilitated, bleeding is reduced. Luijendijk et al. successfully used an inflated condom as a packing device for control of hemorrhage during hepatectomy.[36]

Vander Salm describes two techniques found to be useful in controlling bleeding from the heart during cardiac operations, both of which act by producing local tamponade.[37] The first is similar to Luijendijk's and involves compressing a glove containing a sponge against the bleeding. The second uses high vacuum suction to bring adjacent soft tissue edges together. The author has used these approaches successfully in seven patients in whom other methods had failed to stop bleeding. Berger et al. describe the role of packing the sternotomy wound with sponges followed by primary closure and re-exploration a day later used in three patients with persistent postcardiotomy bleeding.[38] This simple approach reduced bleeding to acceptable levels and facilitated subsequent closure of a dry wound.

Several authors have reported some success in controlling troublesome presacral hemorrhage encountered during pelvic surgery. Xu and Lin have modified cautery in their approach.[39] Rather than apply cautery directly to the bleeding venous complex, they interpose a piece of muscle between the cautery tip and the area of hemorrhage. This produces a coagulum that controls bleeding more successfully than direct electrocautery. Berman has used surgical staples and Appleton et al. have used bone nails.[40,41] Cosman and colleagues successfully controlled bleeding by the use of a tissue expander.[42]

LAPAROSCOPIC SURGERY

The success of laparoscopic cholesytectomy has encouraged surgeons to develop similar alternative approaches to many operations that previously required incision into the chest or abdomen. In many cases, laparoscopic techniques are easier on patients because of smaller incisions, more rapid recovery, and shorter hospital stays. Laparoscopic technique may result in less blood loss from incisional bleeding. Unfortunately, laparoscopic techniques have also given us new complications, including both intraoperative and postoperative bleeding. In the former, bleeding is usually recognized but may be difficult to control through the laparoscope.

Alexander has described two cases of unusual postoperative bleeding after laparoscopic cholecystectomy, both from liver bleeding.[43] Welch et al. describe their difficulties in attempting to remove a porcelain gallbladder with laparoscopic technique.[44] Significant bleeding was caused by retraction, leading to blood transfusion. The authors consider this disease entity a contraindication to laparoscopic approach. Problems with bleeding produced during laparoscopic procedures led Kerbl and Clayman to describe methods for intraoperative application of hemostatic materials through the laparoscope.[45]

Senagore et al. compared 140 elective colonic resections for both benign and malignant disease, with 102 patients undergoing open procedures and 38 laparoscopic.[46] Blood loss was significantly less with the laparoscopic approach: 157 ± 19 mL compared to 687 ± 54 mL for the open cases. Adrenalectomy has been performed through the laparoscope with varying results. Go et al. report a reduction in mean blood loss with laparoscopic adrenalectomy performed in seven patients.[47] Blood loss was between 40 to 500 mL (mean 217.2 mL)–less than one unit of blood. Suzuki et al. have described results with 12 patients who underwent laparoscopic adrenalectomy.[48] Three of these patients had massive bleeding because of technical problems.

Vietz et al. describe a minimally invasive technique of hysterectomy –pelviscopic intrafascial hysterectomy–that leaves the vascularized extrafascial tissue around the cervix intact and minimizes blood loss.[49] Average hemoglobin drop in their group of 60 patients was 1.8 gm/dL. Arbogast et al. have reported on the use of laparoscopically assisted hysterectomy as an alternative to open techniques.[50] Although this approach may reduce blood loss, inadvertent injury to vascular structures may lead to significant bleeding until the abdomen can be opened to gain control.

UROLOGY

Bleeding sufficient to require transfusion during major urologic procedures is not uncommon. Ekengren and Hahn have studied technical factors related to blood loss during transurethral resection of the prostate in a series of 700 patients.[51] Both the length of the operation and the amount of resected tissue were independent predictors of blood loss, which ranged from 10 to 3825 mL with a median of 300 mL. Regional anesthesia was associated with a higher blood loss than general anesthesia, but losses could be reduced with the regional approach if hypotensive techniques (systolic blood pressure maintained at 100 mm Hg or less) were used. Strup et al. analyzed the impact of intermittent pneumatic compression devices on intraoperative blood loss during radical prostatectomy or cystectomy in 91 patients operated on over a five-year period.[52] Fifty-nine patients were treated with intermittent pneumatic compression, while 32 were not, with comparable numbers in each group of prostatectomy and cystectomy patients. Blood loss in the compression group ranged from 700 to 8850 mL with a mean of 2541 mL. In the no-compression group, blood loss was significantly lower with a mean of 1807 mL (range 450 to 5100 mL). Compressed patients received 0.6 units of blood more on average than those who were not compressed.

PLASTIC SURGERY

Blood loss during liposuction can be considerable, and often requires predonation of blood to meet transfusion needs. Courtiss et al. estimated the amount of blood present in tissue aspirated during large volume liposuction to be 30 to 45% depending on the site of fat removal.[53] They transfused their 108 patients with 227 units of autologous blood and only 2 units of allogeneic blood.[53] Klein reported on the role of tumescent anesthetic technique in reducing blood loss to virtually zero during large volume liposuction (greater than 1500 mL of fat).[54] In 112 patients, the mean volume of blood suctioned was 18.5 mL, 9.7 mL for each

liter of fat removed. Mandel found the use of a syringe to perform large-volume liposuction led to less blood loss than vacuum liposuction by machine.[55]

HEMOSTATIC TECHNIQUES

Electrocautery has been used successfully for many years to control intraoperative small vessel bleeding. It is particularly effective in well-vascularized regions such as the head and neck. Tan et al. studied over 500 cases of primary tonsillectomy and adenoidectomy and found that the use of scalpel dissection was associated with more intraoperatiove bleeding and a greater risk of postoperative hemorrhage than the use of cautery.[56]

Trent studied 29 patients undergoing tonsillectomy with each patient serving as his or her own control, comparing electrocautery dissection with an epinephrine/lidocaine injection technique.[57] The author was unable to show any difference between the two groups in intraoperative blood loss or postoperative hemorrhage. This may be because both techniques are effective in reducing bleeding. Trent did not compare either of these approaches with scalpel dissection, which produces greater bleeding.

The use of the laser may either reduce or increase bleeding, depending on the disease being treated and the operation being performed. In a review of 300 patients who underwent either laser-assisted cholecystectomy or laparoscopic cholecystectomy with electrocautery, Corbitt suggested that bleeding was more excessive in the laser-assisted group.[57] Operating time was also longer. Wyman and Rogers performed a prospective, randomized trial of modified radical mastectomy using a neodymium: yttrium-aluminum-garnet (Nd:YAG) laser scalpel compared to a conventional scalpel.[58] Forty consecutive women were randomized to one or the other group. Operative blood loss was significantly less with the laser (149 versus 421 mL) but the mean operating time was approximately 25 minutes longer, leading the authors to question the use of the laser scalpel. Tchabo et al. compared 422 patients equally divided into two groups who underwent cervical conization, 217 with laser and 205 with the cold knife.[59] Use of the cold knife was associated with less intraoperative blood loss. Bhatta et al. conducted a study of various cutting techniques used to perform ovarian wedge resections in rabbits.[60] Scalpel, electrocautery, continuous and pulsed CO_2 and YAG lasers were employed. Electrocautery, CO_2 laser, continuous Nd:YAG laser, and pulsed Ho:YAG laser produced minimal or no bleeding, whereas both scalpel and pulsed Er:YAG laser led to bleeding that required hemostatic measures.

Hemorrhage during and immediately following Caesarean section presents a worrisome problem to the obstetrician. Two recently reported surgical modifications appear to help reduce blood loss during this procedure. Lao et al. modified the incision used in performing Caesarean section to reduce operative blood loss and compared their lower segment approach (LSCS) to conventional section (CCS) in 62 patients.[61] Thirty-one patients in each group were matched for gestational age, type of anesthesia, and tocolytic therapy. Blood loss was significantly less in the LSCS group as was the incidence of severe bleeding. Magann et al. compared manual removal of the placenta to spontaneous removal and in situ versus exteriorized repair of the uterus following Caesarean section to determine differences in blood loss.[62] Position of the uterus during repair had no effect on blood loss, but hemorrhage was significantly less in those patients who had the placenta removed manually compared to spontaneous expulsion.

Advances have been made in head and neck surgery using both variations of familiar techniques as well as new ones. Preoperative embolization is effective in reducing bleeding during resection of nasopharyngeal angiofibroma. Siniluoto et al. studied 10 patients who underwent preoperative nasopharyngeal embolization with Gelfoam, demonstrating that this technique significantly decreased intraoperative blood loss.[63] Average blood loss in non-embolized patients was 1510 mL compared to 510 mL in those who were embolized. El-Silimy and colleagues presented data on 180 patients who underwent inferior turbinate resection as part of a multipart nasal procedure, comparing no nasal pack versus packing kept in place for 24 and 48 hours.[64] The hemorrhage rate was 11.7% for the group with no pack, 8.3% if the pack was kept for 24 hours, and 0% if the packing was left in place for 48 hours. This study shows that packing after turbinate resection can significantly reduce postoperative bleeding.

The choice of anesthetic agent and technique may have an effect on surgical blood loss. Blackwell et al. studied the effect on blood loss of general anesthesia with isoflurane inhalation in 13 patients versus monitored sedation with a continuous intravenous infusion of propofol in 12 similar patients undergoing endoscopic sinus surgery.[65] Blood loss in the isoflurane group was 251 mL compared to a 101 mL loss in the propofol group ($p<.01$). The type of ventilation device used may have an effect on blood loss as well during ENT surgery. Webster et al. compared tracheal intubation to an armored laryngeal airway (LMA) during adenotonsillectomy. Use of the LMA reduced blood loss when compared to conventional techniques (1.92 mL/kg versus 2.62 mL/kg respectively).

In this brief review, an attempt to focus on recent changes in surgical technique has been directed at preventing or controlling operative blood loss, thereby reducing the need for transfusion. Discussion of pharmacological agents such as aprotinin and fibrin glue has been purposefully excluded because of both time and subject limitations. The articles chosen are recent–most were published after 1993–to provide a picture of current efforts in this exciting area of surgical technology. STI

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