CONTRIBUTORS

John J. Doski, MD
Pediatric General and Thoracic Surgery
San Antonio Pediatric Surgery Associates
San Antonio, TX

Stephen P. Dunn, MD
Chief, Division of Pediatric Surgery and Solid Organ Transplantation
AI DuPont Hospital for Children, Dept. of Surgery
Wilmington, DE

Ankush Gosain, MD
Assistant Professor, Division of Pediatric Surgery
University of Wisconsin
Madison, WI

Max R. Langham, Jr., MD
Program Director
University of Tennessee, Division of Pediatric Surgery
Memphis, TN

Eugene D. McGahren, III, MD
Professor,
University of Virginia Health System, Dept. of Pediatric Surgery
Charlottesville, VA

Rebecka L. Meyers, MD
Primary Children's Hospital, Dept. of Pediatric Surgery
Salt Lake City, UT

Gregory M. Tiao, MD
Richard and Geralyn Azizkhan Chair in Pediatric Surgery
Surgical Director, Liver Transplantation
Cincinnati Children's Hospital Medical Center
Cincinnati, OH
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NOTICE

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Attending physicians, residents, fellows, students and providers using this handbook in the treatment of pediatric patients should recognize that this text is not meant to be a replacement for discourse or consultations with the attending and consulting staff. Management strategies and styles discussed within this text are neither binding nor definitive and should not be treated as a collection of protocols.
INTRODUCTION

This handbook describes current surgical management of Liver Tumors. It is based on current literature and accepted practice, and is managed and updated by the APSA Cancer Committee. It is designed to consolidate the most current and up to date material you need to know when treating your patient. Liver Tumor treatment is centered on risk stratification according to PRETEXT and POSTTEXT groupings for staging and assessment of resectability.

This handbook begins with A One Minute Review, is designed for use immediately before an operation and includes abbreviated staging, risk stratification, surgery guidelines, and tissue handling. There follows more descriptive sections for staging and surgical management, including diagrams for PRETEXT staging.

Enrollment on open Children’s Oncology Group protocols, both biology and clinical trials, is strongly encouraged.

Surgery Study members are listed below, and should be contacted for questions. Any and all suggestions for improvement are welcome.

APSA Pediatric Surgical Contacts for Questions:

Rebecka Meyers, Chair  (801) 884-9999  rebecka.meyers@imail2.org
Eugene McGahren  (434) 924-5643  edm6k@virginia.edu
Max Langham, Jr  (901) 572-3300  mlangham@utmem.edu
Stephen P. Dunn  (302) 651-5999  sdunn@nemours.org
Gregory Tiao  (513) 636-4371  greg.tiao@cchmc.org
Christopher Weldon  (617) 913-9019  christopher.weldon@childrens.harvard.edu

Associate Surgeon Members of COG Liver Committee:
Ric Superina, Ash Gosain, Sanjeev Vasudeevan, Dave Lal, Megan Durham, Emily Chistianson-Lagay
ONE-MINUTE REVIEW

PRETEXT
Resection guidelines are determined by PRETEXT (PreTreatment Extent of Disease, assigned at diagnosis before any chemotherapy) or POST-TEXT (Post-Treatment Extent of Disease, assigned after chemotherapy) groupings.

PRETEXT I  Tumor in 1 liver section, 3 adjoining free of tumor
PRETEXT II  Tumor in 2 adjoining sections, 2 adjoining free of tumor
PRETEXT III  Tumor in 3 adjoining sections or 2 nonadjoining, 1 free or 2 nonadjoining free
PRETEXT IV  Tumor involves all 4 liver sections, no section free

*Each PRETEXT group should be annotated with following modifiers, called PRETEXT Annotation Factors:
+V  Involvement of IVC or all 3 hepatic veins
+P  Involvement of portal bifurcation or both right/left portal veins
+E  Extrahepatic contiguous tumor
+M  Distant metastatic disease
+C  Involvement of caudate lobe
+F  Multifocal tumor nodules within the liver
+R  Tumor rupture at diagnosis

SURGICAL GUIDELINES
Surgical Resection of Liver tumor At Diagnosis:
• Liver resection at diagnosis (segmentectomy or hemi-hepatectomy, > 1 cm margin desired for resections done prior to chemotherapy) for PRETEXT I or PRETEXT II with >1 cm radiographic margin on the middle hepatic vein, the retrohepatic IVC, or portal bifurcation (negative V, negative P).
• Tumor biopsy only at diagnosis for PRETEXT II with less than < 1 cm radiographic margin for V and P, or PRETEXT III, PRETEXT IV, or metastatic disease.
  o Biopsy technique at discretion of institution: percutaneous co-axial tru-cut, laparoscopic tru-cut, laparoscopic wedge, or open (minimum biopsy size=3 tru-cut cores. Where possible encourage 5 cores of tumor and 1 core of normal liver: three cores tumor for diagnosis; 2 (or more) and one normal liver frozen for COG biologic study. All patients encouraged to enroll on COG biology studies where possible ).
  o Larger biopsies are better to evaluate for heterogeneous foci of small-cell undifferentiated (SCU) tumor- worse prognosis.
  o Especially important to obtain tumor for biologic study in patients with atypical presentation or age greater than 4 years, or +V, +P, +E, +M, +C, +F, or +R
• Referral to surgical center with expertise in pediatric liver transplantation and “complex liver resection for any PRETEXT with +V, +P, +E, +F, or +R or PRETEXT IV.

Surgical Resection of Liver tumor following initial chemotherapy (2 cycles):
• Hemi-hepatectomy for all POST-TEXT I, POST-TEXT II with >1cm margin and negative –V, -P, -E, -F, - R after 2 cycles
- Referral to surgical center with expertise in pediatric liver transplantation and “complex” liver resection **no later than** after 2 cycles for any POST-TEXT +V, +P, +E, +F, +R or POST-TEXT IV. Goal is complete resection or transplantation within 4 wks of completion 4th cycle

Surgical Resection of Liver tumor after completing full course preoperative chemotherapy (4 cycles):
- Hemi-hepatectomy or Extended Hemihepatectomy for all tumors
- Assistance required from surgical center with expertise in pediatric liver transplantation and complex liver resection for any POST-TEXT +V, +P, +E, +F, +R or POST-TEXT IV. Goal is complete resection or transplantation within 4 wks of completion 4th cycle

**POST-OPERATIVE STAGE**…formerly referred to as “COG” stage, this terminology is **NOT recommended in future studies**
- I Completely resected.
- II Grossly resected with microscopic margin positive, or pre/intra-op rupture.
- III Unresectable, partially resected with measurable tumor left behind; abdominal lymph node involvement
- IV Metastatic disease to lungs, other organs or sites distant from the abdomen

**TISSUE HANDLING**
All tissue obtained in OR sent fresh to pathologist. For biopsy specimens please discuss with pathologist the goal, where possible, of freezing 2 (or more) cores of tumor and 1 core of normal liver for biology studies. Biology especially recommended for a nypatient greater than 4 years of age or any tumor with +V, +P, +E, +M, +C, +F, +R

**PRETEXT Staging System:** Includes PRETEXT Group and PRETEXT Annotation Factors (+V, +P, +E, +M, +C, +F, +R)
STAGING

PRETEXT STAGING

LESIONS FOR PRIMARY RESECTION
TUMORS TO BIOPSY AND REFER TO LIVER SPECIALTY CENTER AT DIAGNOSIS

Resect at Diagnosis
- Rt or Lt lateral Segmentectomy or Hemi-Hepatectomy
- goal of >1 cm margin when resection is done before chemotherapy:
  - PRETEXT I
  - PRETEXT II

Diagnosis CT shows unfocal tumor with at least 1 cm clear radiographic margin from middle hepatic vein and portal bifurcation

TUMORS TO BIOPSY AT DIAGNOSIS AND RESECT BY CONVENTIONAL SURGICAL TECHNIQUES AFTER 2ND OR 4TH CYCLE OF NEOADJUVANT CHEMOTHERAPY
Old COG/Evans Staging, Also called “Post–Surgical” Staging
(Staging system that was used in prior times when COG used to recommend attempt at surgical resection at diagnosis in all patients)

Stage I: Completely resected tumors.
Stage II: Grossly resected tumors with evidence of microscopic residual.
          Resected tumors with microscopic positive margins or pre-operative (intra-operative rupture).
Stage III: Unresectable tumors
          Partially resected tumors with measurable tumor left behind or patients with abdominal lymph node involvement.
Stage IV: Metastatic disease to lungs, other organs or sites distant from the abdomen.

SURGICAL RESECTION GUIDELINES
Surgical resection guidelines are based on the PRETEXT grouping system, which was designed specifically for patients with liver tumors. Terminology for PRETEXT grouping at diagnosis is “PRETEXT”. Extent of disease assignment AFTER chemotherapy is referred to as “POST-TEXT”.

Tumors Considered Resectable at Diagnosis by lateral segmentectomy or simple hemi-hepatectomy (NOT extended hemi-hepatectomy)
- PRETEXT I
- PRETEXT II with >1 cm radiographic margin on the middle hepatic vein, the retrohepatic IVC, and the portal bifurcation.
Tumor Biopsy Only at Diagnosis
- PRETEXT II with less than 1 cm radiographic margin on the middle hepatic vein, the retrohepatic IVC, and/or the portal bifurcation.
- PRETEXT III.
- PRETEXT IV
  - Biopsy technique at discretion of institution: percutaneous co-axial tru-cut, laparoscopic tru-cut, laparoscopic wedge, or open (minimum biopsy size=3 tru-cut cores. Where possible encourage 5 cores of tumor and 1 core of normal liver: three cores tumor for diagnosis; 2 (or more) and one normal liver frozen for COG biologic study. All patients encouraged to enroll on COG biology studies where possible).
  - Larger biopsies are better to evaluate for heterogeneous foci of small-cell undifferentiated (SCU) tumor- worse prognosis.
  - Especially important to obtain tumor for biologic study in patients with atypical presentation or age greater than 4 years, or +V, +P, +E, +M, +C, +F, or +R

Tumors Considered Resectable for Standard (Not extended) Hemi-hepatectomy After First 2 Cycles of C5VD Neoadjuvant Chemotherapy
- Tumors with POST-TEXT I.
- Tumor with POST-TEXT II with >1 cm radiographic margin on the middle hepatic vein, the retrohepatic IVC, or the portal bifurcation.

Tumors with Potential Need for Liver Transplant or Extreme Resection
- Major Venous Invasion: Unifocal PRETEXT III with tumor invasion of all 3 hepatic veins or the retrohepatic vena cava (V), or both main branches of the portal vein (P). The distinction between major venous “invasion” by tumor vs major venous “displacement” or “extrinsic compression” by tumor can be radiographically very difficult. Clinicians are encouraged to err on the side of “possible invasion” and refer patient for transplant evaluation if this distinction is very difficult to make.
  - Unifocal PRETEXT IV
  - Multifocal PRETEXT III and IV
  - Refer to surgical center with expertise in pediatric liver transplant and complex liver resection at diagnosis if possible and no later than just after the first 2 cycles of C5VD neoadjuvant chemotherapy have been completed. Resection planning is to be completed before completion of the 4th cycle of chemotherapy. Transplant or “extreme” resection is to occur within 4 weeks of completing the 4th cycle of chemotherapy.

Tumors Considered Resectable for Hemihepatectomy, or Extended HemiHepatectomy, or MesoHepatectomy Within 4 weeks of Completing 4th Cycle of Chemotherapy
- Tumors with POST-TEXT III and no non-resectable hepatic venous or portal venous invasion. The surgeon must anticipate the ability to achieve a negative surgical margin on the right or left hepatic vein, retrohepatic IVC, and right or left portal vein. With surgical resection after chemotherapy, margin may be less than 1 cm if the surgeon feels a complete resection will be feasible without transplant and patient has completed 4
cycles of C5VD chemotherapy.

Tumors Presenting with Metastatic Disease (PRETEXT annotation factor = positive “M”)  
- For all others, proceed with 2, or 4, cycles of C5VD  
- Repeat radiographic imaging after completing first 2 cycles of C5VD  
- Hemihepatectomy after 2 cycles chemotherapy for all tumors downstaged to POST-TEXT Group I, II and >1 cm radiographic margin on right/left hepatic vein, retrohepatic IVC, and portal bifurcation., PRETEXT annotation factor negative V,P,E,F,R  
- Hemihepatectomy/ Extended Hemihepatectomy/ or Mesohepatectomy after 4 cycles chemotherapy for all tumors downstaged to POST-TEXT Group II,III, and any positive V,P,E,F,R surgeon considers resectable without transplantation  
- For patients potentially needing liver transplant, POST-TEXT IV or any positive V,P,E,F,R surgeon considers unresectable, refer to surgical center with expertise in pediatric liver transplant and “extreme” liver resection at diagnosis if possible and no later than after 2 cycles of C5VD. Resection planning is to be completed before completion of Cycle #4  
- Repeat chest CT scan must demonstrate complete clearance of pulmonary metastatic disease within 1 week prior to liver transplant.  
- Those patients with persistent extrahepatic disease, may be resected (not transplanted) at the discretion of the surgical center with expertise in pediatric liver transplant and “extreme” liver resection.  
- Those patients with persistent extrahepatic disease who are not anatomically resectable without transplantation will continue chemotherapy and/or be referred for phase II chemotherapy options

Surgical Management of Pulmonary Metastasis
For patients presenting with pulmonary metastatic disease (PRETEXT annotation factor = positive “M”) will receive the “up-front” window chemotherapy for high-risk patients, if metastases disappear with chemotherapy, no pulmonary surgical intervention will be performed. If metastases are persistent after 4 total cycles of C5VD chemotherapy and the patient is considered a candidate for liver transplant at that time, metastases are to be resected to render the patient free of extrahepatic disease prior to transplant. Transplant may then be undertaken.

If the liver tumor can be surgically resected (hemihepatectomy/extended hemihepatectomy/ or mesohepatectomy), resect after Cycles 4. After surgical resection of liver tumor, complete cycles 5, and 6 of chemotherapy. For any lung metastases still present after 6 cycles of chemotherapy, surgery for pulmonary metastectomy may be performed. Also, acceptable if needed for pulmonary metastectomy to be performed earlier in the course of therapy if it can be done without resulting in delays in the administration of scheduled chemotherapy.

Guidelines for Liver Transplant for Hepatoblastoma
    Chemotherapy. Patients should be treated with standard on-study chemotherapy protocols with the same number of cycles of chemotherapy, before and after transplant, as patients submitted to partial hepatectomy. Extended courses of chemotherapy aimed at alleviating the need for transplantation are not recommended. Extended and prolonged preoperative exposure to chemotherapy risk the induction of chemotherapy resistance genes, a well described phenomenon in HB
**Multifocal PRETEXT IV.** Even with good response to chemotherapy accompanied by POST-TEXT down-staging, total hepatectomy followed by liver transplantation is the only way to ensure clearance of all microscopic foci. Radiographic clearance of a section does *not* guarantee total obliteration of microscopic residual in multifocal disease, and any residual disease may be stimulated by hepatocyte growth factors after major resection (33).

**Solitary POST-TEXT IV.** Large, solitary, PRETEXT IV tumors may occasionally downstage to a POST-TEXT III and become resectable. When the ability to preserve adequate normal liver is in question, the decision for transplant versus resection should be made by a liver specialty team with the capability of liver transplantation.

**Vascular Invasion, PRETEXT III +P, +V.** With macroscopic vascular invasion the tumor may *not* become resectable, even after a good response to chemotherapy. Central tumors involving Couinaud’s segments 4, 5, 8 can have close contact with the main portal vein, portal bifurcation and all three hepatic veins. Central hepatectomy, or “meso-hepatectomy” may be possible in experienced centers, but should not be attempted without the full support and safety net of a transplant team. Resection when the tumor abuts major venous structures may be possible. Resection when the tumor invades major venous structures runs the risk of uncontrolled bleeding, tumor residual, and compromise of vascular inflow and/or outflow. Radiographic imaging cannot always reliably distinguish between the two situations. With either a resection or a transplant, invaded areas of retrohepatic vena cava should be resected en bloc and reconstructed either with autologous internal jugular vein, donor iliac vein, or a preserved cadaveric whole organ with donor IVC.

**Transplant in Patients with Metastatic Tumor at Diagnosis.** If metastases clear after chemotherapy or surgical resection children are still eligible for transplant. Conversely, persistence of viable extrahepatic tumor nodules after neoadjuvant chemotherapy, if not amenable to surgical resection, is an absolute contraindication to transplantation. Some have recommended manual palpation of lungs pre-transplant. Others have recommended very high resolution CT, and even PET-CT, with very meticulous preoperative scrutiny of the lungs. Unresponsive or progressive metastatic disease in the face of neoadjuvant chemotherapy is a relative contraindication to transplant because even if the nodules can be surgically resected microscopic foci of chemoresistant tumor are highly probable (16,30,34).

**Rescue Transplant for Relapse vs Persistent Tumor.** Multiple series have shown superior outcome after primary transplant (about 80% overall survival) when compared to rescue transplant (about 35% overall survival). Although detailed data are missing, a distinction should be made between two distinct types of “rescue” transplant. When gross residual tumor persists after a failed attempt at partial hepatectomy, prompt progression to a rescue transplant may have a favorable outcome with the assumption that adjuvant chemotherapy may control any spillage of malignant cells outside of the liver. In contrast, local tumor relapse remote from the initial resection suggests possible chemotherapy resistance and debilitated patient status and transplant results may be inferior.

**Radiographic Imaging**

**CT SCAN.** All CT scans should be done with technical factors using the lowest radiation exposure possible (ALARA principle) that allow optimal image quality. CT slice *acquisition* thickness should be 1.5 mm or less. Post-contrast IV enhanced portal venous phase abdominal and pelvic CT should be performed from just above the diaphragm to the symphysis pubis. Dual
phase (arterial and portal venous) abdominal CT is strongly recommended. Oral contrast is strongly recommended.

**MRI.** Axial images and coronal images of the liver tumor should be acquired with at least two pulse sequences, including T1 and either fat-suppressed T2, STIR, or fat-suppressed fast/turbo imaging. Gadolinium should be given if appropriate and if there is normal renal function. After contrast administration T1W, fat-suppressed, axial images should be obtained. Based on patient age, images may be non-breath-hold or breath-hold, including respiratory triggered or respiratory gated. Dual phase MRI may be performed at the discretion of the local radiologist. To perform dual phase MR, gadolinium-enhanced imaging is performed in combination with dynamic gradient echo sequences. After contrast agent injection, images are obtained through the liver during the arterial phase (20 to 30 seconds post injection), portal venous phase (60 to 80 seconds after injection), and at equilibrium (3 to 5 minutes after injection). Delayed images can be obtained if needed for further lesion characterization.

**Metastatic Site Imaging.** Chest CT is required to evaluate metastatic disease. Chest CT may be performed without intravenous contrast material. The diameter of a "measurable" nodule should be at least twice the reconstructed slice thickness. Smaller nodules are considered detectable, but will be counted as "non-measurable. Bone scan is not required but should be considered in symptomatic patients with bone pain or bone lesions. Metastatic disease to bone and bone marrow is extremely rare and should only be considered if the patient is symptomatic with unexplained bone pain or unexplained cytopenias.

**Hepatic Arterial Chemoembolization (HACE) TransArterial ChemoEmbolization (TACE).** Experience is less in children than adults, but this modality is increasingly used for tumors that are unresectable and not candidates for transplant due to metastatic disease. Although complications with the older lipiodol technique were frequent, chemoembolization is now possible with doxorubicin-eluting beads and Itrium-theraspheres offering hope for children with unresectable tumors, when liver transplantation is not an option. Resection might be facilitated as unifocal tumors become firm and calcified.

**Pre-Operative Portal Venous Embolization.** Preresection portal venous embolization has been used in adults with HCC to induce hypertrophy of the remaining liver remnant and results of this technique have been reported in children. This technique may be particularly useful in children with large unifocal tumors with limited remaining normal liver. The portal venous branch on the side of the tumor is embolized with polyvinyl alcohol and coils. This has the dual effect of alcohol thrombosis of the embolized tumor and compensatory hypertrophy of the unharmed opposite liver lobe increasing the hepatic functional reserve.

**Surgeon Responsibilities:**

**Dictated Operative Report should include:**
- Demographics (name, date, surgeon, pre and postoperative diagnosis, operation)
- Type of Resection: Segmentectomy, HemiHepatectomy, Extended HemiHepatectomy, Mesohepatectomy, Liver Transplant, Non-Anatomic resection
- Couinaud Liver segments involved by tumor
**Technical Aspects of Surgical Resection**

Terminology of surgical resection now follows the Brisbane classification: Segmentectomy; Hemi-hepatectomy, Extended Hemi-Hepatectomy, MesoHepatectomy, and Liver Transplant.

Assessment of resectability with excellent working knowledge of liver anatomy requires high quality, contrast-enhanced CT and/or MRI. PRETEXT determines tumor resectability at diagnosis; POST-TEXT determines tumor resectability after chemotherapy. Most tumor shrinkage seems to occur with the first 2-cycles of cisplatin chemotherapy. POST-TEXT I can be resected with a segmentectomy and POST-TEXT II with a hemihepatectomy. POST-TEXT III is resected with extended hemihepatectomy (formerly called trisegmentectomy) or mesohepatectomy. Any tumor with bilobar macrovascular invasion (+V,+P) or extensive parenchymal obliteration (PRETEXT IV) is best managed at a center with experience in liver resection and liver transplant.

Specialized equipment options include ultrasonic CUSA-type dissector, Ligasure (Covidien), water knife (Hydro-jet, ERBE), argon or infrared bean coagulator, and intraoperative ultrasonography. Intraoperative ultrasonography helps to ensure that resection margins are clear and evaluates for satellite lesions in multifocal tumors. The procedure begins with mobilization and anatomic definition of the extent of the tumor, of any satellite lesions, and of any suspicious areas of vascular involvement. Sampling of lymph nodes from the hepatoduodenal ligament and any other areas of suspicion is performed. Portal vein and hepatic artery inflow and suprahepatic vena cava outflow are defined prior to parenchymal dissection. In rare situations hepatic veins can be secured towards the end of parenchymal resection and accessed through liver parenchyma, but this is done only after the surgeon is certain that the remaining inflow and outflow vessel branches are safe and secure from harm. Once inflow and outflow are ligated, parenchymal dissection is often possible along the line of ischemia. Blood loss can also be minimized by maintenance of a low central venous pressure (CVP) and Trendelenburg position. Inflow occlusion (Pringle maneuver), outflow occlusion (suprahepatic clamp), or both, can safely be applied for short periods. Warm ischemia in short intervals limited to 10-15 minutes with intervening 5 – 10 minute periods of reperfusion and recovery is better tolerated than uninterrupted longer periods of occlusion. During and after dissection of the parenchyma various techniques of local hemostasis can be applied including LigaSure, harmonic scalpel, vascular clips, bipolar coagulation, argon beam, infrared coagulation, and one of many commercially available topical thrombostatic agents.
Incomplete tumor resection and macroscopic tumor residual has been associated with worse outcome. Whenever there is any doubt, and particularly when one suspects macroscopic residual, the surgeon should biopsy and re-resect the margin by taking an extra slice, or if necessary an additional segment, of liver. Sometimes the actual margin may be difficult to interpret because of a thick eschar of burned tissue at the margin from the use of electrocautery. Cautery artifact partially explains the lack of local relapse in many patients with positive microscopic margin. Alternative explanations include: 1) chemosensitive microscopic residual is killed by postoperative chemotherapy; 2) a CUSA resection margin may have been vacuumed up and thus not analyzed; or 3) microscopic residual found on the operative specimen has no counterpart on the remaining liver. Although a microscopic positive margin may, in select cases, be compatible with survival, it should never be the goal of a thorough and complete liver resection. If a resection free margin, obtained safely and without danger to the inflow/outflow vasculature, cannot be anticipated with a high degree of confidence, liver transplantation is preferred.

Atypical, non-anatomic, or wedge resections are not recommended. In two consecutive GPOH multicenter trials, HB89 and HB94, 38% of the patients with an atypical resection were found to have post resection residual tumor and this was associated with a worse outcome. Possible explanations include dissemination of tumor cells in the liver after atypical resection, the presence of unappreciated microscopic vascular invasion or satellite foci, and the known role of hepatocyte growth factor (HGF) stimulating post resection liver regeneration and residual tumor cell proliferation. Atypical liver resections are justified in very selected cases only, mainly of multifocal tumors, when liver transplantation is precluded by metastatic disease.

Surgical Complications Liver Resection
Potential surgical complications of major liver resection include bleeding, impairment of blood flow in or out of the liver, bile blockage or leak, liver failure, infection.

Bleeding and major vessel injury
Bleeding from needle biopsy can almost always be stopped with correction of clotting factors and with direct pressure. In contrast, massive bleeding during complex tumor resection may be life threatening. Bleeding risk is minimized by avoiding inappropriate aggressive attempts at tumor resection in proximity to major vessels. In the event of a failed initial resection, reoperation is associated with increased perihepatic bleeding with adhesions to the diaphragm, retroperitoneum, and right adrenal gland. Unrecognized anatomic origin of a replaced right or left hepatic artery may lead to bleeding or inappropriate ligation. Normal liver can occasionally survive permanent interruption of arterial or portal venous inflow, but not both. In the rare instance that both portal and arterial inflow of the remaining liver tissue has been disrupted, survival requires immediate revascularization or transplant. Loss of adequate venous drainage from the residual liver remnant will cause congestion and loss of parenchymal viability. It’s important to prevent inadvertent hepatic venous occlusion with ill-placed sutures into the hepatic parenchyma in an attempt to control bleeding.

Cardiac arrest
Intraoperative cardiac arrest occurs in 1-2% of major liver resection procedures. The most common cause is uncontrolled massive blood loss. Close communication between the operative surgeon and anesthesiologist is of paramount importance in not allowing the patient to develop
life-threatening hypovolemia. Cardiac arrest may also occur from tumor emboli or, more commonly, an air embolus from an uncontrolled hole in the IVC or major hepatic vein. Risk of an air embolism can be minimized by the use of higher PEEP (Positive End-Expiratory Pressure) settings during the suprahepatic vein and IVC dissection portion of the procedure. It is also very important to preoperatively evaluate cardiac function in all patients who have been treated with doxorubicin as their baseline cardiac function may be compromised.

**Liver failure**
Potential causes of postoperative liver failure include small liver remnant, liver devascularization, interruption of venous drainage, excessive liver warm ischemia due to prolonged vascular occlusion or massive bleeding, major bile duct obstruction, halogenated anesthetic agents, viral infections, and drug reactions. Unless definitive signs of improvement are seen in the first few days, liver transplantation may need to be considered.

**Bile leak**
Bile leak occurs in 10-12% of cases and its frequency has not decreased over the years. The bile ducts, particularly at the level of the hilum, are more easily disrupted than the vessels. If a minor injury is recognized it can usually be directly repaired. Major injury with loss of ductal wall, complete division, or loss of length mandates debridement back to healthy, well-perfused ducts and drainage with a Roux-en-y limb of jejunum. Bile leak from the cut surface is minimized by close inspection and avoiding non-anatomic resection. When any question of potential leak exists a retrograde cholangiogram, before closure of the abdominal wall, is recommended both to detect leaking biliary radicals and confirm appropriate drainage of all remaining segments. Although placing drains at the time of operation does not lessen the rate of bile leakage, it facilitates postoperative management. Bile leaks that do not respond to appropriate drainage are almost always associated with distal obstruction, such as a retained section of viable liver excluded from the biliary drainage system, iatrogenic occlusion (clip, ligature, thermal injury), hematoma, stone, residual obstructing tumor, or ischemic stricture.