J Gastrointest Surg (2016) 20:748–756
DOI 10.1007/s11605-015-3041-7

ORIGINAL ARTICLE

Symptomatic Perihepatic Fluid Collections After Hepatic Resection in the Modern Era

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Received: 28 August 2015 / Accepted: 23 November 2015 / Published online: 7 December 2015

Abstract
Background Improvements in liver surgery have led to decreased mortality rates. Symptomatic perihepatic collections (SPHCs) requiring percutaneous drainage remain a significant source of morbidity.
Study Design A single institution's prospectively maintained hepatic resection database was reviewed to identify patients who underwent hepatectomy between January 2004 and February 2012.
Results Data from 2173 hepatectomies performed in 2040 patients were reviewed. Overall, 200 (9 %) patients developed an SPHC, the majority non-bilious (75.5 %) and infected (54 %). Major hepatic resections, larger than median blood loss (≥360 ml), use of surgical drains, and simultaneous performance of a colorectal procedure were associated with an SPHC on multivariate analysis. Non-bilious, non-infected (NBNI) collections were associated with lower white blood cell (WBC) counts, absence of a bilio-enteric anastomosis, use of hepatic arterial infusion pump (HAIP), and presence of metastatic disease, and resolved more frequently with a single interventional radiology (IR) procedure (85 vs 46.5 %, $p<0.001$) more quickly (15 vs 30 days, $p=0.001$).
Conclusions SPHCs developed in 9 % of patients in a modern series of hepatic resections, and in one third were non-bilious and non-infected. In the era of modern interventional radiology, the need for re-operation for SPHC is exceedingly rare. A significant proportion of minimally symptomatic SPHC patients may not require drainage, and strategies to avoid unnecessary drainage are warranted.

Keywords Hepatic resection · Symptomatic perihepatic fluid collections · Non-bilious, non-infected collections · Interventional radiology drainage

This study was presented at the American College of Surgeons meeting on September 28, 2014, at San Francisco, CA.

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Introduction

Over the last few decades, significant improvements in hepatic surgery have decreased mortality rates after hepatic resection to under 5 % in high-volume hepatobiliary centers.[1–5] However, liver surgery is still associated with a significant morbidity rate that varies between 32 and 45 %.[1,2,4,5] Symptomatic perihepatic fluid collections (SPHCs) requiring percutaneous drainage constitute a significant portion of this morbidity.[1,2,4–6]

Routine placement of abdominal drains in the subphrenic or subhepatic space after partial hepatectomy, in an attempt to prevent an SPHC or for detection of bleeding or bile leak, has been standard practice for decades. We abandoned the routine placement of intraoperative drains since five randomized controlled trials[7–11] and a subsequent meta-analysis[12] found no evidence to support the routine use of drains after uncomplicated liver resections. Most of the recent studies addressing the risk factors and management of postoperative SPHC focus specifically on bile leaks.[13–18] The results of these studies have been variable and often conflicting in terms of risk factors for and management of bile leaks. Moreover, bile leaks are reported to be associated with re-operation rates as high as 4 % and with perioperative mortality rates as high as 45 %.[13–18] The risk factors for all SPHC remain poorly defined, and no discrete risk factors have been identified. Furthermore, analysis of non-bilious/non-infected (NBNI) collections is important because drainage of these may be avoided or simple aspiration may be performed. Detailed data regarding specific interventional radiologic issues around the drainage of SPHC have also not been well described.

Since the report of our randomized trial demonstrating no benefit from routine intraoperative drainage after elective liver surgery,[8] we last updated our experience over 10 years ago with an audit showing that our policy of selective intraoperative drain placement has not led to any obvious adverse outcomes.[19] Results from that study showed operative drainage, and the extent of hepatic resection were predictors of development of a SPHC.

The aim of the present study was to analyze a large modern series of hepatic resections and to evaluate the incidence and detailed interventional radiologic management of postoperative SPHC. We sought to identify specific groups of patients at high risk for SPHC and analyze factors associated with bilious, infected, or NBNI collections.

Materials and Methods

Patient Selection and Preoperative Evaluation

After approval from the Institutional Review Board of Memorial Sloan Kettering Cancer Center (MSK), a prospectively maintained hepatic surgery database was queried to identify patients (age ≥18 years) who underwent an elective hepatic resection between January 2004 and February 2012. The starting date was chosen because it was from this point onward that all perioperative complications were recorded prospectively rather than retrospectively. Patients who underwent open or laparoscopic surgical exploration, with or without liver biopsy or ablation only, were excluded.

The routine preoperative assessment of patients scheduled to undergo hepatic resection at MSK includes a full medical history and physical examination, cardiopulmonary evaluation in patients with serious comorbidities; laboratory tests, including liver function; and cross-sectional imaging. Parenchymal-sparing resections were used when feasible.[1] Indications for resection of benign and malignant liver tumors have been published previously.[20,21]

Surgical Technique and Postoperative Care

For major resections, inflow vascular control was obtained by division of the extrahepatic inflow vessels or by ligation of the intrahepatic pedicles according to the preference of the operative surgeon, whereas hepatic venous outflow control was typically achieved extrahepatically before dividing the liver parenchyma.[22] Intermittent porta hepatis clamping (Pringle maneuver) was used selectively. Parenchymal transection was performed with a clamp-crushing technique with clipping and tying of significant vessels. More recently, additional techniques for dividing and securing small vessels/bile ducts, such as ultrasonic dissection (CUSA, Tyco Healthcare, Mansfield, MA, USA), TissueLink dissecting sealer (TissueLink Medical, Inc., Dover, NH, USA), and LigaSure (Valley Lab, Tyco Healthcare, Boulder, CO, USA), were used with greater frequency, at the discretion of the operating surgeon.[23–25] Resections were performed under low central venous pressure (CVP) (CVP <5 cm H_20) anesthesia. After the resection was completed, patients were typically rehydrated in the operating room and hemostasis was obtained. Intraoperative ultrasound was routinely used. Postoperatively, most patients were monitored overnight in the recovery room and then transferred to the ward, provided they were clinically stable.

Definitions of Resections

The type of hepatic resection was classified using the Brisbane 2000 terminology.[26]

A major resection was defined as resection of three or more segments. A central hepatectomy was defined as a resection of segments 4, 5, and 8. Other atypical resections that could not be described per the Brisbane terminology were coded as either minor or major resections depending on the number of segments resected.

When multiple hepatic procedures were performed, the most extensive resection was considered the main procedure. Repeat resection was defined as any resection performed in a patient who had previously undergone a partial hepatectomy. Extrahepatic procedures performed at the time of liver surgery were recorded. Placement of a hepatic arterial infusion pump (HAIP) and the performance of additional thermal ablation(s) at the time of resection were also recorded.

Surgical Drains and Interventional Radiology Drains

Intraoperative drains were left selectively, at the discretion of the attending surgeon. The most common reasons for leaving an intraoperative drain were a concomitant

Table 1 Clinicopathologic characteristics from 2173 elective hepatic resections

Characteristic	*N*=2173 (%)
Median age (years, range)	59 (18–91)
Female gender	1081 (50)
Preoperative chemotherapy	1119 (52)
Type of hepatic resection	
Major hepatic resection	864 (40)
Right hepatectomy ± resection of segment 1	324 (15)
Right trisectionectomy ± resection of segment 1	202 (9)
Left hepatectomy ± resection of segment 1	181 (8)
Left trisectionectomy ± resection of segment 1	66 (3)
Central hepatectomy (segments 4, 5, and 8)	20 (1)
Other non-anatomical major resections	71 (3)
Minor hepatic resection	1309 (60)
Right anterior sectionectomy	11 (0.5)
Right posterior sectionectomy	124 (6)
Left medial sectionectomy	141 (7)
Left lateral sectionectomy	135 (6)
Segmentectomy	408 (19)
Other minor resections	490 (23)
Prior hepatic resection	300 (14)
Surgical drains used	294 (14)
Simultaneous procedures	
Colorectal surgery	334 (15)
Other gastrointestinal surgeries (stomach, duodenum, small bowel)	87 (4)
Gynecologic procedures[a]	74 (3)
Bilio-enteric anastomosis	106 (5)
HAIP	404 (19)
Surgical ablation (RFA/MWA)	239 (11)
Diagnosis	
1. Primary liver malignancy	327 (15)
Hepatocellular carcinoma	193 (9)
Cholangiocarcinoma	110 (5)
Other	24 (1)
2. Extrahepatic biliary malignancy	177 (8)
Hilar cholangiocarcinoma	59 (3)
Gallbladder carcinoma	116 (5)
Distal cholangiocarcinoma	2 (0.1)
3. Metastatic liver malignancy	1530 (70)
Colorectal	1189 (55)
Other	341 (16)
4. Benign disease	139 (6)
Adenoma	20 (1)
Focal nodular hyperplasia	20 (1)
Hemangioma	27 (1)
Other	72 (3)
Any complication	784 (36)
Major complication	276 (13)
Perihepatic collection requiring IR-guided drainage	200 (9)

[a] Typically either total abdominal hysterectomy and/or unilateral or bilateral salpingoophorectomy

HAIP hepatic arterial infusion pump, *RFA/MWA* radiofrequency ablation/microwave ablation, *IR* interventional radiology

Table 2 Postoperative symptomatic perihepatic collections in 2173 elective hepatic resections

	N (%)
Symptomatic perihepatic collections	200 (9)
Surgical drains used	68 (23)
Type of collection fluid	
Bilious	49 (24.5)
Non-bilious	151 (75.5)
Presence of infected collection	
Infected	108 (54)
Non-infected	92 (46)
Non-bilious non-infected collection	69 (34.5)
Predrainage data	
WBC (10^3/μl, range)	11.2 (2.4–40.8)
Total bilirubin (mg/dl, range)	1.1 (0.3–15.3)
Size of collection on CT (cm, range)	9.9 (2.4–21.8)
Drainage data	
Drainage quantity (ml, range)	200 (10–1650)
Tissue plasminogen activator (tPA) use	18 (9)
Additional IR-guided procedure	80 (40)
Drain exchange	51 (64)
Drain upsize	28 (35)
Re-drainage	34 (43)
Re-operation	
Bile leak	1/200 (0.5)

biliary reconstruction, persistent bile leakage from the cut surface of the liver, or diaphragm resection.[8] The reason for use of a surgical drain and the need for additional interventional radiology (IR) procedures were recorded.

SPHC identified on imaging were drained percutaneously under radiologic guidance. The gross characteristics of the fluid were recorded, and samples from the drained collections were routinely sent for culture and sensitivity evaluation. Percutaneous drains were typically either 8.5 or 10 F, all-purpose pigtail drains and were exchanged or upsized as needed to provide optimal drainage. Transcatheter tissue plasminogen activator (tPA) was selectively used to facilitate drainage of loculated and complex collections that were not completely evacuated at the initial postdrainage scan.

Symptomatic Perihepatic Collections

Identification of SPHC by computed tomography (CT) prompted IR-guided drainage. All collections that underwent IR-guided drainage were reviewed, and those located perihepatically and associated with liver resection were classified as SPHC. Collections judged to be distant from the liver and related to extrahepatic procedures were not categorized as SPHC.

The SPHC were characterized as infected when the drained fluid was positive for microbial culture. SPHC were coded as bilious when the drained fluid was grossly bilious or had an elevated fluid bilirubin level three times higher than the serum level even though this measurement was infrequently used (19 % of SPHC). Clinical and pathologic variables were analyzed for their association with the development of SPHC. NBNI collections were compared to the rest of the collections in an effort to identify differences. Postoperative complications were entered prospectively into the Department of Surgery complication database (MSK Surgical Secondary Events Program)[27] by physicians directly involved in the patients' care.

Statistical Analysis

Statistical analysis was conducted using SPSS software (version 20.0; SPSS, Chicago, IL). Continuous variables are presented as median and range. Categorical or dichotomous data are presented as frequencies and percentages, as appropriate. The association of variables with SPHC was tested using the chi-squared test or Fischer's exact test, as appropriate, for dichotomous covariates and the *t* test for continuous variables. Stepwise logistic regression was used for multivariate models.

Results

Clinicopathologic Characteristics

Between January 2004 and February 2012, 2173 consecutive elective partial hepatectomies were performed in 2040 patients. The median age at the time of hepatectomy was 59 years (range 18–91), and 1081 (50 %) of the patients were female (Table 1). Major hepatectomies were performed in 864 (40 %) patients and repeat hepatectomies in 300 (14 %). An intraoperative drain was placed in 294 (14 %) patients. The most common concomitant extrahepatic procedures were HAIP placement (19 %) and colorectal surgery (15 %). The most common indication for hepatic resection was colorectal cancer liver metastases (55 %). Overall, 788 (36 %) patients experienced a postoperative complication (13 % major complications). The mortality rate within 90 days was 2 %.

Symptomatic Perihepatic Collections: Characterization and Management

Overall, 271 (12 %) patients were evaluated for a postoperative abdominal collection that necessitated drainage, and 200 (9 %) of these patients were characterized as SPHC, the details of which are outlined in Table 2.

Table 3 Factors associated with postoperative symptomatic perihepatic collections in 2173 partial hepatectomies

Factors	SPHC+ (*n*=200)	SPHC− (*n*=1973)	*p* value Univ	*p* value Multiv
Demographics				
Age ≥59 (years)	112 (56)	1013 (51)	0.2	
Female gender	99 (50)	982 (50)	0.94	
Preoperative labs				
Albumin ≥4.2 (g/dl)	106 (53)	1197 (61)	0.09	
Bilirubin ≥0.6 (mg/dl)	115 (58)	1050 (53)	0.3	
AST ≥230 (IU/l)	121 (61)	935 (47)	0.001	0.14
Preoperative chemotherapy	111 (56)	1008 (51)	0.24	
Operation data				
Major hepatic resection	122 (61)	742 (38)	<0.001	<0.001
Prior hepatic resection	34 (17)	266 (14)	0.2	
Operative time ≥226 (min)	143 (72)	942 (48)	<0.001	0.06
EBL ≥360 (ml)	147 (74)	941 (48)	<0.001	0.001
FFP transfusion	38 (19)	265 (13)	0.03	0.5
PRBC transfusion	35 (18)	245 (12)	0.04	0.8
PLT transfusion	5 (3)	55 (3)	1	
HAIP	34 (17)	370 (19)	0.63	
Surgical ablation (RFA/MWA)	19 (10)	220 (11)	0.48	
Extrahepatic surgery				0.002
Colorectal	46 (23)	288 (15)	<0.001	
Other gastrointestinal	9 (5)	78 (4)	0.7	
Surgical drain			<0.001	<0.001
Bilio-enteric anastomosis	38 (19)	68 (3)		
Intraoperative bile leak	11 (6)	42 (2)		
Extrahepatic organ surgery	19 (10)	116 (6)		
Primary tumor histology			<0.001	0.06
Primary liver cancer	24 (12)	303 (15)		
Extrahepatic biliary cancer	35 (18)	142 (7)		
Metastatic liver cancer	135 (68)	1395 (71)		
Benign disease	6 (3)	133 (7)		

SPHC symptomatic perihepatic collections, *Univ* univariate analysis, *Multiv* multivariate analysis, *AST* aspartate aminotransferase, *EBL* estimated blood loss, *FFP* fresh frozen plasma, *PRBC* packed red blood cells, *PLT* platelets, *HAIP* hepatic arterial infusion pump, *RFA/MWA* radiofrequency ablation/microwave ablation

Sixty eight (23 %) of these patients had a perihepatic drain placed intraoperatively. In the majority of patients, the drained fluid was non-bilious (75.5 %) and infected (54 %), whereas 69 (34.5 %) of the collections were NBNI. The percentage of infected fluid was similar between bilious and non-bilious collections (53 vs 55 %, respectively; p=0.87). The median size of the collections on CT was 9.9 cm. Eighty patients (40 %) required additional IR procedures after the initial drainage, most frequently drain exchanges (64 %) for catheter malfunction and/or repositioning for optimization of drainage. Additional IR procedures were more frequently needed for bilious (63 vs 32.5 %, $p<0.001$) and infected collections (54 vs 24 %, $p<0.001$). A single patient required an endoscopic retrograde cholangiopancreatography (ERCP) for a bile leak; however, this was related to a documented postoperative distal biliary stricture. None of the other patients required ERCP for resolution of their bile leak. One patient (0.5 % of all collections or 0.05 % of all operations) required re-laparotomy to control a persistent bile leak.

Symptomatic Perihepatic Collections: Risk Factors

Table 3 lists the factors associated with the development of an SPHC. In multivariate analysis, major hepatic resection, greater than median (360 ml) blood loss, concomitant colorectal procedure, and placement of a drain at the time of surgery were significantly associated with the development of SPHC.

Table 4 Surgical drains in 294 patients: indications and need for additional procedures

	N=294 (%)
Intraoperative indication	
Bilio-enteric anastomosis	106 (36)
Intraoperative bile leak	53 (18)
Extrahepatic organ surgery	
Diaphragm	81 (28)
Colorectal	33 (11)
Duodenal resection	13 (4)
Pancreatic resection	6 (2)
Small bowel	2 (1)
IR-guided drainage of symptomatic perihepatic collection	68 (23)
Type of drained fluid	
Bile leak	26 (38)
Non-bilious	42 (62)
Presence of infected collection	46 (68)

IR interventional radiology

Most (61 %) of the SPHC developed after a major hepatic resection. Among major resections, there was no statistically significant difference between the type of resection and the rate of an SPHC (data not shown). Among bisectionectomies, right anterior sectionectomies were more frequently associated with SPHC (27.3 %), whereas the risk was much smaller for right posterior sectionectomies (12.1 %), left medial sectionectomies (9.2 %), and left lateral sectionectomies (2.2 %) ($p=0.003$).

Even though primary tumor histology was only marginally associated with SPHC on multivariate analysis ($p=0.06$), operations for extrahepatic biliary cancers were associated with the highest risk of an SPHC (19.8 %) compared to operations for benign disease, which had the lowest risk (4.3 %).

Surgical Drains

The presence of a surgical drain was a strong predictor of development of a postoperative SPHC, with the risk being greater if the drain was placed for a bilio-enteric anastomosis (36 %) than for a bile leakage identified intraoperatively (21 %) or an extrahepatic organ surgery (14 %) ($p<0.001$) (Table 3).

The reasons for intraoperative drain placement in 294 patients and the additional IR procedures performed in 23 % of these patients are detailed in Table 4. Table 5 demonstrates factors associated with the need for

Table 5 Factors associated with the need for additional IR drainage in 294 hepatic resections with surgical drains used

Factors	Additional IR drain (N=68)	No additional IR drain (N=226)	p value
Reason for surgical drain			<0.001
Bilio-enteric anastomosis	38 (56)	68 (30)	
Intraoperative bile leak	11 (16)	42 (19)	
Extrahepatic organ surgery	19 (28)	116 (51)	
Operation data			
Major hepatic resection	57 (84)	124 (55)	<0.001
Prior hepatic resection	9 (13)	32 (14)	0.85
FFP transfusion	20 (29)	50 (22)	0.22
PRBC transfusion	16 (24)	51 (23)	0.87
PLT transfusion	3 (4)	11 (5)	0.88
Associated procedures			
HAIP	1 (2)	27 (12)	0.01
Surgical ablation (RFA/MWA)	1 (2)	11 (5)	0.21
Extrahepatic surgery			
Colorectal	8 (12)	31 (14)	0.68
Other gastrointestinal	4 (6)	18 (8)	0.57
Histology			0.24
Primary liver cancer	12 (18)	32 (14)	
Extrahepatic biliary cancer	28 (41)	70 (45)	
Metastatic liver cancer	25 (37)	106 (47)	
Benign disease	3 (4)	18 (8)	

IR interventional radiology, *FFP* fresh frozen plasma, *PRBC* packed red blood cells, *PLT* platelets, *HAIP* hepatic arterial infusion pump, *RFA/MWA* radiofrequency ablation/microwave ablation

Table 6 Factors associated with the development of non-bilious, non-infected collections among 200 symptomatic perihepatic collections

Factors	NBNI SPHC (n=69)	Other SPHC (n=131)	p value
Median age (years)	61	60	0.9
Female gender	34 (49)	67 (51)	0.8
Surgical drain			0.003
Bilio-enteric anastomosis	4 (6)	34 (26)	
Intraoperative bile leak	1 (1)	10 (8)	
Extrahepatic organ surgery	9 (13)	10 (8)	
Predrainage data			
WBC (10^3/μl, range)	9.9 (3.3–24.2)	12.4 (2.4–40.8)	0.03
Total bilirubin (mg/dl, range)	1.1 (0.3–14)	1.1 (0.3–14)	0.36
Size of collection on CT (cm, range)	8.6 (2.4–18.5)	10.3 (3–21.8)	0.16
Drainage quantity (ml, range)	150 (10–1650)	200 (10–1300)	0.5
Additional IR procedures	10 (14.7)	69 (53.5)	<0.001
Duration of drainage (days)	15 (6–98)	30 (3–568)	0.001
Operative data			
Major hepatic resection	39 (57)	82 (63)	0.3
Right major resection	30 (44)	54 (41)	0.8
Left major resection	8 (12)	21 (16)	0.5
Prior hepatic resection	8 (12)	26 (20)	0.1
Simultaneous procedures			
HAIP	19 (28)	15 (12)	0.004
Colorectal surgery	17 (25)	29 (22)	0.69
Histology			0.006
Primary liver cancer	6 (9)	18 (14)	
Extrahepatic biliary cancer	6 (9)	29 (22)	
Metastatic liver cancer	57 (83)	78 (60)	
Benign disease	0 (0)	6 (5)	

NBNI non-bilious and non-infected, *SPHC* symptomatic perihepatic collection, *WBC* white blood cell (count), *CT* computed tomography, *HAIP* hepatic arterial infusion pump

additional IR-guided drainage among patients with surgical drains. A major hepatic resection (with similar rates for right and left major resections (34.5 vs 26 %; p=0.2)) and the reason for the surgical drain placement (bilio-enteric anastomosis (36 %) vs intraoperative bile leak (21 %) or extrahepatic organ surgery (14 %) (p<0.001)) were significantly associated with the need for additional IR-guided drainage.

Non-bilious, Non-infected Collections

A comparison of NBNI with the other SPHC is demonstrated in Table 6. Patient demographics as well as the percentage of repeat and major resections were similar. NBNI collections were most frequently associated with a normal predrainage white blood cell (WBC) count, whereas the diameter of the collection measured on CT and the volume of drained fluid were similar.

NBNI collections were associated with metastatic disease and HAIP placement, whereas bilious and/or infected collections were most frequently associated with primary and extrahepatic cancers and the presence of a surgical drain for a bilio-enteric anastomosis. NBNI resolved more frequently with a single IR-guided drainage procedure (85 vs 46.5 %, p<0.001) in a shorter time period (15 vs 30 days, p=0.001).

An SPHC occurring in a patient who underwent hepatectomy for extrahepatic biliary cancers with presence of a surgical drain for a bilio-enteric anastomosis and an elevated ($>11\times10^3$/μl) WBC count had an 88 % probability of being bilious and/or infected. A SPHC occurring in a patient who underwent hepatectomy for metastatic cancer, without a surgical drain, with placement of HAIP, and with a normal WBC count had a 54 % probability of being NBNI.

Discussion

Liver surgery has undergone significant changes over the last two decades. Advances in operative technique, patient selection, and perioperative care have contributed to a significant decrease in perioperative mortality rates, which are generally well under 5 % in major hepatobiliary centers.[1–5] Morbidity after hepatic resection remains a significant problem, and postoperative SPHC represents one of the most significant complications. While the routine use of operative drains is still practiced in many institutions, several surgical groups, including ours, advocate a selective use based on prospective randomized trials[7–11] showing no benefit with routine intraoperative drainage. Furthermore, intraoperative drains have been associated with an increase in rates of infectious complications[9] and of SPHC, which require further drainage.[7] In this context, it is important to elucidate the risk factors for and management of SPHC in the modern era.

In the present study, 9 % of the hepatic resections were complicated by an SPHC requiring IR-guided percutaneous drainage postoperatively. This is in line with our previous experience where 10 % of patients with no surgical drains were drained percutaneously.[19] More importantly, in the era of modern interventional radiology, the need for re-operation for a SPHC was exceedingly rare (0.5 % of all SPHCs, 0.05 % of all cases). Additionally, it is rarely, if ever necessary to perform an ERCP for an uncomplicated bile leak as this was not required for resolution of any case in this series. Major hepatic resections, high estimated blood loss (EBL), synchronous colon surgery, and surgical drains, especially when placed for a bilio-enteric anastomosis, were associated with SPHC. Major hepatic resections and the presence of bilio-enteric anastomosis were also associated with need for additional IR-guided drainage in patients with surgical drains in place. Other studies have found similar associations between the extent of resection, blood loss, and bile duct resection with a surgical drain and the development of a bile leak.[4,17]

The presence of a SPHC does not always correlate with the presence of a bile leak or an infection, and in this study, 35 % of drained collections were NBNI. Since some SPHC are minimally symptomatic and these symptoms may not be related to the collection, it is likely that some of these collections potentially could be treated conservatively with non-drainage or aspiration alone. In the present study, the vast majority (86 %) of NBNI resolved with a single IR-guided drainage and required shorter duration of drainage compared with bilious and/or infected collections. Even though at present we cannot reliably distinguish between those SPHC that are NBNI and those that are not, infected and/or bilious collections were associated with the creation of a bilio-enteric anastomosis and an increased WBC count. NBNI collections were associated with normal WBC count and metastatic histology. Their association with HAIP placement likely represents the physicians' discretionary lowering of the threshold at which to drain collections, in an attempt to protect the pump from the consequences of an infectious complication near a foreign body.

With advances in IR and the ability to easily upsize, exchange, and generally manage (with tPA) malfunctioning percutaneously placed drains as well as replace poorly working surgical drains, the need for re-operation for a SPHC has almost been eliminated, being only 0.5 % of the SPHC or 0.05 % of all resections in this cohort. This is in contrast with recent studies that report re-operation rates for bile leaks ranging from 12.6 to 15.3 %.[3,14] Re-operation in this setting is associated with significant mortality rates, as high as 45 % in a recent series.[14]

The limitations of our study are related mainly to its retrospective nature. However, we have a large, modern patient cohort, and there were no major institutional changes in patient care during the examined period. Importantly, postoperative complications were recorded prospectively and reviewed at a biweekly morbidity conference with the attending surgeons. The low rate of bile leaks in this series may be attributed to the infrequent use of surgical drains and to not measuring bilirubin routinely from those drains. Thus, small, clinically insignificant leaks are not detected.

Conclusion

In conclusion, in a modern large series of hepatic resections managed with selective intraoperative drainage, symptomatic perihepatic collections developed in 9 % of cases and were associated with major resections, high EBL, synchronous colorectal surgery and use of surgical drains; especially for a bilio-enteric anastomosis. Non-bilious, non-infected collections were associated with normal WBC count, metastatic disease histology, HAIP placement, and absence of a bilio-enteric anastomosis. More accurate identification of these collections, especially in minimally symptomatic patients, may spare these patients a drainage procedure. In the era of modern interventional radiology, the need for re-operation for SPHC, including bile leaks, is exceedingly rare.

Compliance with Ethical Standards

Grant Support This study was supported in part by NIH/NCI Cancer Center Support Grant P30 CA008748.

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