Elective and Emergency Hepatic Resection

Determinants of Operative Mortality and Morbidity

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To determine the reasons for improved mortality and morbidity rates after major hepatic resection, five variables were analyzed retrospectively in 300 patients operated on over a 27-year period: (1) the indication for surgery, (2) the surgical approach, (3) the urgency with which surgery was performed, (4) the nature of the surgical procedure, and (5) the experience of the surgeon. The operative mortality rate decreased from 19% between 1962 and 1979 to 9.7% between 1980 and 1988 ($p < 0.05$). The operative mortality rates for patients undergoing resection for benign hepatic neoplasms was 3.4%; for metastatic tumors, 6.3%; for primary hepatic malignancies, 19%; and for trauma, 33%. Fifty-seven percent of operations before 1980 were performed through a thoracoabdominal exposure as compared with 19% after 1980. Overall a thoracoabdominal exposure of the liver was associated with a 20% mortality rate as compared with 8.6% for operations with abdominal exposure of the liver ($p < 0.02$). Elective operations accounted for 65% of hepatic resections before 1980, as compared with 90% after 1980, and were associated with an 8.8% mortality rate as compared with 30.7% for urgent and emergency operations ($p < 0.001$). Segmental and wedge resections were associated with a 5.3% mortality rate as compared with 14.7% for major hepatic resections ($p < 0.05$), but this difference did not affect overall operative mortality rates because there was no change in the proportion of major hepatic resections after 1980. Surgical experience was not a determinant of operative mortality or morbidity rates in elective operations. Although there was no reduction in the complication rate after 1980, there was a reduction in postoperative stay from 26 days before 1980 to 16 days after 1980 ($p < 0.001$). A reduction in the incidence of postoperative sepsis and a change in its management was associated with improved operative mortality rates.

HEPATIC RESECTION benefits patients if the risks of death and complications are outweighed by relief of symptoms and by improved length and quality of survival. This study of hepatic resection assessed the reasons for improved survival rates and reduced morbidity rates over a 27-year period.

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Materials and Methods

Patients

Patients (n = 478) who underwent a liver resection from January 1962 through December 1988 were identified by computer search of all charts in the medical records department and the pathology department for patients undergoing hepatic resection. Three hundred charts were selected for inclusion in this study, representing patients who had had a major hepatic resection, for example, right or left hepatectomy, extended hepatectomy, or segmentectomy. Results of wedge excision of hepatic tumors also were included if surgery was curative. The reasons for exclusion of 178 charts were wedge excision of one of many hepatic metastases (n = 41), liver biopsy examination for benign disease (n = 37), hepatic transplantation (n = 49), minor liver resection *en bloc* with other abdominal malignancy (n = 40), drainage of an abscess or cyst (n = 7), and donor hepatectomy (n = 4).

Demographic, clinical, operative, and radiologic data were collected by review of the hospital chart and of the surgeons' office records. Full data were obtained for 98.4% of patients. An operative death was defined as death attributable to the surgical procedure or to its complications, whether it occurred in the hospital or later. Morbidity was defined as any untoward event during recovery from surgery, as determined by scrutiny of the medical notes and radiologic and biochemical reports.

Classification

Couinaud's classification of hepatic resection was used regardless of the nomenclature used in the operative report.[1,2] Right hepatectomy was removal of segments V,

VI, VII, and VIII. Extended right hepatectomy removed all of these plus segment IV. Left hepatectomy was removal of segments II, III, and IV. Extended left hepatectomy was resection of segments II, III, and IV with segments V and VIII, or with segments VI and VII. Segmental resection was defined as an anatomic resection of one or more segments including left lateral segmentectomy (excision of segments II and III), and wedge resection as a minor nonanatomic resection.

Operations were classified as *emergency* if the patient's condition necessitated immediate surgery for the control of hemorrhage. If the patient was admitted as an emergency case, but underwent a period of stabilization and investigation before operation, the operation was classified as *urgent*. All other operations were classified as *elective*.

Statistical Analysis

Data were organized into two groups: 1962 through 1979 (18 years, 84 operations) and 1980 through 1988 (9 years, 216 operations). Statistical analysis was performed by the chi square test or by Fisher's exact test for 2×2 tables. Student's t test was used to analyze variables in the postoperative stay, and results were expressed as mean $\pm$ standard error of the mean (SEM). Statistical significance was stipulated for two-tail p-values < 0.05.

Results

From 1962 to 1988, the number of hepatic resections increased from 29 operations between 1962 and 1970 to 55 operations between 1971 and 1979, and to 216 operations between 1978 and 1988 (Fig. 1).

Deaths

The operative mortality rate in the period 1962 to 1980 was 19%, as compared with 9.7% in the period 1980 to 1988 ($p < 0.05$). Overall the rate of fatal complications was 12.3%. The causes of death were hemorrhage (9), hepatic failure (12), subphrenic sepsis (2), pneumonia (3), septicemia (5), myocardial infarction (1), renal failure (1), and associated trauma (4). Five parameters affecting operative mortality rates were analyzed. These were the indication for surgery, the surgical approach used, the urgency with which surgery was performed, the extent of the surgical procedure, and the experience of the surgeon.

Indication for Resection

The operative mortality rate of patients undergoing resection of benign hepatic neoplasms was 3.4%; for metastatic tumors, 6.3%; for primary hepatic malignancies, 19.1%; and for post-traumatic liver resections, 33.3%. After 1980 the mortality rates were lower for patients with metastatic disease and zero for benign hepatic neoplasms, whereas the mortality rates for primary hepatic malignancy and trauma increased (Table 1). The proportion of liver resections performed for metastatic disease increased from 26% before 1980 to 49% after 1980. Before 1980, 20 liver resections (24%) were performed for trauma as compared with 13 liver resections (6%) after 1980.

Surgical Approach

Four surgical approaches were used for hepatic resection: (1) an abdominal approach (n = 210), (2) a thora-

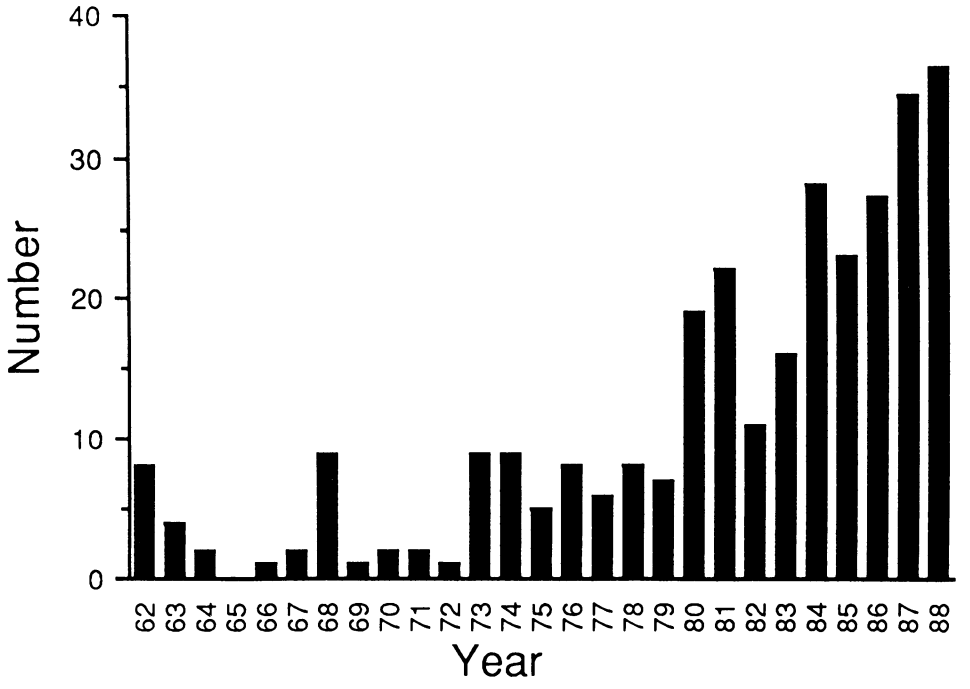

FIG. 1. Number of hepatic resections by year.

TABLE 1. *Operative Death Rate (%OD) for Patients Undergoing Hepatic Resection*

Indication	1962–1988		1962–1979		1980–1988	
	n	%OD	n	%OD	n	%OD
Primary hepatic malignancy	68	19.1	19	15.8	49	20.4
Hepatocellular carcinoma	42	23.8	14	21.4	28	25.0
Cholangio/gallbladder carcinoma	12	8.3	3	0	9	11.1
Hepatoblastoma	3	0	2	0	1	0
Sarcoma	11	9.1	0	0	11	9.1
Metastases	126	6.3	22	13.6	104	4.8
Benign hepatic tumors	59	3.4	17	11.8	42	0
Hepatic adenoma	12	16.7	2	100	10	0
Focal nodular hyperplasia	15	0	6	0	9	0
Cavernous hemangioma	26	0	5	0	21	0
Benign connective tissue tumor	6	0	4	0	2	0
Hepatic trauma	33	33.3	20	25	13	46.1
Miscellaneous	14	21.4	6	50	8	0

coabdominal approach (n = 65), (3) an abdominal operation extended by a lower sternal split (n = 20), and (4) an abdominal approach extended by a full median sternotomy (n = 5). Thoracoabdominal hepatic resection was associated with a 20.0% mortality rate (n = 90) as compared with 8.6% (n = 210, $p < 0.02$) for abdominal exposure alone. Before 1980 57% of hepatic resections were performed through a thoracoabdominal incision, as compared with 19.4% after 1980 ($p < 0.001$). For both abdominal and thoracoabdominal operations, operative mortality was lower after 1980 (Table 2).

The maximal dimension of tumors resected by a thoracoabdominal approach was 10 cm (median; range, 0.6 to 28 cm), as compared with 6 cm (range, 0.4 to 26 cm) for hepatic resection performed through an abdominal incision alone (NS, Mann-Whitney U test). Solitary tumors were resected in 62% of hepatectomies performed through an abdominal incision as compared with 66% of hepatectomies performed through a thoracoabdominal incision (NS).

Urgency of Operation

Elective operations were associated with a threefold lower mortality rate (8.8%, n = 249) as compared with urgent operations (26.7%, n = 15) or emergency operations (30.6%, n = 36, $p < 0.001$, Table 2). Elective operations accounted for only 65% of hepatic resections before 1980 as compared with 90% of operations after 1980. Urgent or emergency hepatic resection was performed through a thoracoabdominal incision in 49% of patients and through an abdominal incision in 51% (NS).

Nature of Resection

Segmental and wedge resections imposed a mortality rate of only 5.3%, as compared with 14.7% for major resections ($p < 0.05$). No significant differences in mortality rates were associated with different extents of major hepatic resection. The operative mortality rates were lower for all types of hepatic resection except extended right hepatectomy, when comparing the period 1962 to 1979

TABLE 2. *Operative Deaths (%OD), Surgical Approach, and Urgency of Operation*

Variable	1962–1988		1962–1979		1980–1988	
	n	%OD	n	%OD	n	%OD
Exposure						
Abdominal	210	8.6	36	13.9	174	7.5
Thoracoabdominal						
Lower medial sternotomy	20	15.0	0	0	20	15.0
Thoracoabdominal	65	20.0	46	21.7	19	15.8
Median sternotomy	5	60.0	2	50.0	3	66.7
Urgency of operation						
Elective	249	8.8	55	12.7	194	7.7
Urgent	15	26.7	7	42.9	8	12.5
Emergency	36	30.6	22	27.3	14	35.7
Urgent and emergency	51	29.4	29	31.0	22	27.3
Exposure and urgency						
Elective abdominal	184	6.5	27	3.7	157	7.0
Elective thoracoabdominal	65	15.4	28	21.4	37	10.8
Urgent/emergency abdominal	26	11.5	9	44.4	17	11.8
Urgent/emergency thoracoabdominal	25	36.0	20	25.0	5	80.0

TABLE 3. *Extent of Hepatic Resection and Operative Death Rate (%OD)*

Extent of Resection	1962–1988		1962–1979		1980–1988	
	n	%OD	n	%OD	n	%OD
Major						
Right hepatectomy	102	14.7	28	25.0	74	10.8
Left hepatectomy	52	15.4	18	27.8	34	8.8
Extended right hepatectomy	61	14.7	14	14.3	47	14.9
Extended left hepatectomy	9	11.1	1	100	8	0.0
Total	224	14.7	61	24.6	163	11.0
Minor						
Segmental resection	47	6.4	16	6.2	31	6.4
Wedge resection	29	3.4	7	0.0	22	4.5
Total	76	5.3	23	4.3	53	5.7

with 1980 to 1988 (Table 3). Major resections accounted for 72.6% of hepatic resections before 1980 as compared with 75.5% after 1980 (NS).

Surgical Experience

The range of hepatic resection performed by 54 surgeons was 1-to-131. The operative mortality rate of patients of surgeons who had performed fewer than 10 operations was 16.4%, as compared with 10.0% for more experienced surgeons (NS). For elective operations only, surgeons who had performed fewer than 10 resections had an operative mortality rate of 9.4% as compared with 8.5% for more experienced surgeons. Major resections accounted for 79% of operations performed by surgeons with experience of more than 10 operations, as compared with 67% for less experienced surgeons.

Reoperations

Of 300 patients, 47 (15.7%) underwent 57 reoperations; 15 patients died. The indications for reoperation were postoperative bleeding (18), drainage of subphrenic sepsis (25), exploratory laparotomy (4), operations for wound complications (4), and tracheotomy (8). The reoperation rate was 25% before 1980, as compared with 12.0% after 1980 ($p < 0.005$). In addition, 20 patients (6.7%) underwent 22 percutaneous drainage procedures for intra-abdominal abscesses or collections, and 12 patients (4%) underwent percutaneous drainage of pleural effusions. Before 1980 subphrenic sepsis was treated with reoperation in 15 patients, with a 25% mortality rate. After 1980, subphrenic sepsis was treated by percutaneous drainage in 16 patients and reoperation in 10 patients, with a mortality rate of 2.8%.

Morbidity

Of the 263 patients surviving surgery, 97 (36.9%) patients suffered a total of 209 complications. Local complications comprised subphrenic abscess (20), bile leak (20), postoperative bleeding (9), sterile perihepatic collection (9), enterocutaneous fistula (5), and prolonged ileus (2). Pleural effusion was the commonest pulmonary complication, occurring in 23 patients; other pulmonary complications were pneumonia (7), pneumothorax (4), empyema (3), and respiratory failure requiring tracheotomy (2). Wound infection occurred in 10 patients and wound dehiscence in 2. Metabolic complications occurred in 17 patients; reversible hepatic failure occurred in 14 and renal failure in 3. Of the cardiovascular complications, deep venous thrombosis occurred in two patients and pulmonary emboli in three. Postoperative myocardial infarction and cerebrovascular accident occurred in one patient each. Miscellaneous complications occurred in 27 patients. These included gastrointestinal bleeding (7), septicemia (3), pelvic abscess (2), urinary tract infection (7), and retention of urine (2). Transfusion hepatitis and radial nerve palsy occurred in one patient each.

There was a reduction in the rate of local, pulmonary, and wound complications in the period 1980 to 1988, as compared with 1962 to 1979. Local complications occurred in 29% of patients before 1980, as compared with 20% after 1980. The rate of pulmonary complications was 21.4% before 1980 as compared with 9.7% after 1980. Similarly wound complications occurred in 7.1% of patients before 1980 as compared with 2.8% of patients after 1980.

When analyzed by indication for surgery, there were no significant differences in operative morbidity, comparing 1962 to 1979 with 1980 to 1988. Thoracoabdominal incisions were associated with a morbidity rate of 44.6% as compared with 28.6% for abdominal operations ($p < 0.025$). The rate of pulmonary complications with a thoracic approach was 21.1% as compared with 9.5% for the abdominal approach ($p < 0.01$). Similarly the rate of subphrenic sepsis was 16.5% for thoracic operations as compared with 4.3% for abdominal exposures ($p < 0.02$). There was no significant difference in the morbidity rate for elective operations (31.7%) as compared with the rate for urgent or emergency operations (35.3%).

Extended hepatectomy was associated with a morbidity rate of 45.7% ($p < 0.01$), as compared with 28.3% for all other operations ($p < 0.01$). Segmental or wedge resections were associated with the lowest morbidity rate (15.8%, $p < 0.001$). There were no differences in operative morbidity when analyzed by experience of the surgeon.

Postoperative Stay

The mean (±SEM) postoperative stay was 18 ± 1.0 days. Before 1980 the postoperative stay was 26 ± 2.5 days, as compared with 16 ± 0.9 days after this date ($p < 0.001$). The postoperative stay over the final 2 years of the study fell to 13 ± 1.0 days. The postoperative stay for elective operations was 17 ± 0.8 days, as compared with 29 ± 4.0 days for urgent or emergency operations ($p < 0.01$). After major hepatic resections, the postoperative stay was 20 ± 1.3 days, compared with 14 ± 1.1 days for segmental or wedge excisions ($p < 0.001$).

Discussion

At our hospital five trends in hepatic surgery were associated with reduced operative mortality rates over a 27-year period: an increase in the frequency of operations, a change in the indications for surgery with an increase in the proportion of operations for lower-risk indications, a trend away from resection of the liver through a thoracoabdominal incision, an increase in elective surgery, and a change in the incidence and management of postoperative sepsis. The nature or extent of the operative procedure and the experience of the surgeon, however, were not associated with the improvement in operative mortality seen in recent years.

Hepatic resection is now performed more frequently because operative mortality rates have fallen in the last 30 years. In the 1960s operative mortality rates of 36%,[3] 35%,[4] and 29%[5] were reported. The poor long-term survival and high operative mortality rates of patients undergoing hepatic resection for metastases led to the belief that surgery was indicated for the palliation of symptoms only.[5] One study in 1963, however, demonstrated that resection of hepatic metastases in suitably selected cases was attended by an operative mortality of only 4% and a 5-year survival rate of 30%,[6] and subsequent studies have reported a reduction in operative mortality rate in recent years for hepatic resection.[7-11]

The increased frequency of hepatic resection and improvement in operative mortality was associated with a relative change in the indications for operation. For patients undergoing liver resection of metastases from colorectal cancers, operative mortality rates under 10%[12-23] and between 10% and 15% have been reported.[24-26] The 5-year survival of patients undergoing resection of hepatic metastases from colorectal cancer is 25%.[27] Metastases to a resectable part of the liver from a colorectal primary cancer therefore have become established as an indication for liver resection; this event is reflected in a rise in both the total number and in the proportion of hepatic resections performed for this indication. Because hepatic resection for metastatic disease is attended by a lower operative mortality rate than is hepatic resection for trauma and primary malignant hepatic neoplasms, the consequence of the increase in hepatic resections for colorectal cancer metastases is a reduction in overall operative mortality rate for hepatic resection.

Hepatic resection for benign hepatic neoplasms is attended by operative mortality rates under 6%.[3,28-31] In contrast hepatic resection for primary hepatic malignancy and trauma is associated with greater operative risk. For hepatocellular carcinoma and other primary malignant neoplasms, an early review reported an operative mortality rate of 20%.[32] Operative mortality rates between 20% and 30%[8,33,34] and 10% to 20%[35-42] are more frequently encountered than operative mortality rates under 10%[43-50] for resection of primary malignant hepatic neoplasms. The reduction in overall operative mortality rates seen after 1980, however, was not related to a change in the proportion of patients undergoing resection for benign or primary malignant hepatic neoplasms, because the proportion of resections performed for these indications remained constant.

Although operative mortality rates for patients sustaining injuries to the liver is reported between 5% and 13%,[11,51-53] for the small number of patients requiring hepatic resection for such injuries, the operative mortality rates are 36%,[54] 47.6%,[55] and 83%.[56] We report an overall operative mortality rate of 33% for patients undergoing hepatic resection for hepatic trauma: four of the eleven patients died from associated injuries and, when these deaths are excluded, the operative mortality rate was 21%. The mortality rate of hepatic trauma has been reported to parallel the number of associated injuries.[51] Although we report an increase in the operative mortality rate of the small number of patients undergoing hepatic resection for hepatic trauma after 1980, the reduction in the relative proportion of patients undergoing hepatic resection for trauma reduced the overall operative mortality rate for hepatic resection.

Advances in surgical technique, as shown by a trend away from the use of a thoracoabdominal incision for liver resection, are also a major influence on operative mortality rates. A thoracoabdominal approach to liver resection was associated with a 4% operative mortality rate in 1963.[6] Since this time, however, the use of a thoracoabdominal approach has been associated with a twofold increase in operative blood loss and blood transfusion requirements[57] and an increase in mortality and morbidity rates.[13,57,58] A thoracic extension is now almost never required for hepatic resection.[59]

Although we report a reduction in operative mortality rates for both abdominal and thoracoabdominal operations after 1980, the operative mortality rate for thoracoabdominal operations was twice that for abdominal operations even after 1980. The use of a thoracic extension to the incision may indicate a more complex or difficult operation. There were no differences in the size or number of tumors resected by the abdominal approach as compared with the thoracoabdominal approach, however; surgical preference appeared to be the determinant of the choice of incision. The trend toward abdominal exposure of the liver therefore was a major influence on overall operative mortality rates.

Emergency operations are attended by higher operative mortality rates than are elective operations.[54,60] Such operations are often performed in patients whose general condition is poor and who require surgery to save life or palliate symptoms. The increasing frequency with which hepatic resection is performed was associated with an increase in the proportion of elective operations. The threefold lower mortality rate associated with elective hepatic resection therefore was a major factor in the overall reduction in operative mortality rates.

We report, as have others,[40,61–65] that segmental or wedge resection was associated with a mortality rate half that of major hepatic resection. Minor resections of the liver for metastatic cancer are not associated with worse long-term survival.[66] Because there was no trend toward segmental and wedge resection of the liver over the 27-year period, however, the extent of surgical procedure did not influence the operative mortality rate.

Greater surgical experience may be expected to be associated with lower operative mortality rates after hepatic resection. More experienced surgeons, however, may undertake surgery in higher-risk patients or in patients whose lesions are difficult to excise. Lower operative mortality rates were found in the patients of surgeons who had performed more than 10 hepatic resections. Nonetheless this difference was less evident when the data were analyzed for elective operations only and suggests that a greater proportion of emergency resections were performed by less experienced surgeons. A greater proportion of resections performed by surgeons with experience of more than 10 operations were major resections, and the higher operative mortality rates of such resections may account for the small differences in operative mortality rates between the more experienced and the less experienced surgeons. Therefore for elective hepatic resection, the number of hepatic resections performed by a surgeon is not a guide to operative mortality rates.

Morbidity rates after hepatic resection may be determined by the complication rate, the reoperation rate, and the length of postoperative stay. Complication rates of between 12.5%[13] and 62%[23] have been reported after hepatic resection and are higher after major hepatic resection.[14,63,67] Although we report no change in complication rates over the 27-year period, the reoperation rate, the length of postoperative stay, and the rates of pulmonary complications and subphrenic sepsis have fallen. Because both pulmonary complications and subphrenic sepsis rates are greater with thoracoabdominal exposure of the liver, the reduction in these complications was due to the trend away from this approach to liver resection.

A change in the management of complications after hepatic resection also has resulted in reduced operative mortality rates. Open drainage of subphrenic sepsis was associated with a 25% mortality rate before 1980. After 1980, a combination of percutaneous drainage techniques and open operation was associated with much lower operative mortality rates. These data are consistent with a previous report showing a 37% mortality rate associated with reoperation and 14% mortality rate for sepsis treated initially with percutaneous drainage after hepatic resection.[54]

Conclusion

Adson and Weiland[49] stated that "the risk of routine or standardized major hepatic resection is less than 3 percent. However the risk involved in trying too hard or in resecting inadvisedly is 50 percent or more." We report data consistent with this statement. The recent reduction in operative mortality rate is associated with an increase in the frequency of hepatic resection, an increase in the proportion of elective operations for lower-risk indications, and a change in the surgical approach away from thoracoabdominal incisions. Although complication rates have changed little, a reduction in the reoperation rate and postoperative stay demonstrate the decrease in morbidity rates in recent years from hepatic resection.

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