Audit

Resource and manpower calculations for the provision of hepatobiliary surgical services in the UK

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Background: The provision of specialist non-transplant hepatobiliary services in the UK is fragmented and there is little consensus on the manpower and resource requirements to meet the needs of defined populations.

Methods: We report our experience with a hepatobiliary service established 5 years ago in Sheffield to provide a tertiary referral service to the population of the North Trent health area and attempt to provide estimates of resource requirements based on patterns of current use.

Results: A total of 615 patients with hepatobiliary conditions requiring specialist treatment were referred to the service during 1997–2002. The majority of patients (69%) were referred for consideration of liver resection for colorectal liver metastases. In all, 251 resections were performed in 240 (39% of all referred) patients. The current operation rates for colorectal metastases are about 4 per 100,000 population per year and for other complex hepatobiliary procedures are also 4 per 100,000 population per year giving a total 'need' of 8 procedures per 100,000 population per year. For the current population in England and Wales, this would mean 25 specialist hepatobiliary centres performing in total approximately 2000 hepatic resections for colorectal cancer metastases and 2000 other tertiary hepatobiliary procedures each year.

Conclusions: Our experience supports the model of centralisation of non-transplant hepatobiliary surgical services and indicates the extent of hitherto unmet demand in our geographical area. We estimate that a minimum of two full-time specialist hepatobiliary surgeons with appropriate ancillary support are required for a typical population of 2 million people in the UK.

Key words: Hepatobiliary surgical services – Resources – Manpower – Colorectal liver metastases

Gastrointestinal surgery in the UK is increasingly becoming sub-specialised into upper and lower gastrointestinal surgery with the management of patients being based on a multidisciplinary team approach. Upper gastrointestinal surgery is further divided into hepatopancreato-biliary surgery (HPB) and oesophago-gastric surgery.¹ Most upper gastrointestinal surgeons treat

patients with benign conditions affecting all these organs, but malignant conditions of the liver, bile duct and pancreas are increasingly dealt with by HPB surgeons 'super-specialising' in these organ systems. It is expected that a multidisciplinary approach to the management of upper GI cancer will allow better quality of care and decision-making and there is some evidence that

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centralisation of services in specialised units allowing a higher throughput of cases improves clinical outcomes.^{2,3} The recently published guidance document⁴ on *Improving Outcomes in Upper Gastrointestinal Cancers* addresses these issues in cancers of the oesophagus, stomach and pancreas; however, similar guidance on cancer of the biliary system and liver has not been provided so far.

The main indication for hepatic resection in the UK is metastatic disease from colorectal carcinoma. Although the clinical effectiveness of this treatment is proven beyond doubt in large studies¹⁸ and it is accepted as the treatment of choice in patients who are suitable candidates, there has been a slow uptake of this treatment in the UK. This could be partly due to a degree of pessimism regarding outcomes in terms of survival¹¹ once patients develop metastatic disease and partly due to a lack of appropriate expertise and equipment. Currently, many patients who could potentially be offered single stage curative resection of their liver metastases may not be offered this treatment outside a few centres. Although much less frequently seen, hepatocellular carcinoma and cholangiocarcinoma are the next most common hepatobiliary cancers and some benign liver lesions also require resection if they cause significant symptoms.

Development of the Sheffield programme

Hepatic resections have been conducted in Sheffield over a number of years, albeit at a low level of activity. Hospital data suggest that approximately six hepatic resections per year were conducted in the Sheffield area in the 5 years before this specialist service was developed.⁵ The development of the Sheffield Hepatobiliary Programme occurred in three phases. In 1996, a proposal was put to the Trustees of the Royal Hallamshire Hospital to develop a hepatobiliary surgical service on the basis that there was considerable unmet need in the North Trent area.

During the initial period (1996–1997), the Royal Hallamshire Hospital provided 'start-up' funds for the purchase of equipment and treatment of the first 60 patients, as well as the appointment of a research nurse to collate data and provide support for these patients. Colorectal Multidisciplinary Teams (MDTs) were in the process of becoming established and provided suitable forums for discussions on referral protocols and generally facilitated the referral process. The second phase began in 1998 when, following encouraging results of the initial 60 cases, the hospital approached commissioners from the health authorities in the North Trent area to seek funding for continuation of the service. To inform the decision-making process, a cost effectiveness review was carried out.⁵ The conclusions of this review supported the commissioning of additional hepatic surgery for colorectal metastases. Subsequently, criteria were agreed with the local cancer network for liver resection for

metastases from colorectal cancer. It was agreed that surgery would be commissioned for patients meeting the following criteria: (i) metastases completely resectable with curative intent; (ii) no distant (extrahepatic) metastases; and (iii) no significant co-morbidity. By the end of 1999, funding was in place to implement the service. The third phase (2000 to the present) represents a 'consolidation' phase of this service where activity has begun to stabilise and from which it is possible to make some predictions about likely resource requirements for similar services elsewhere.

Summary of operative results

The majority of patients (69%) were referred for consideration of liver resection for colorectal liver metastases. Others represented a variety of conditions including cholangiocarcinoma, hepatocellular carcinoma, gallbladder cancer, benign biliary strictures and symptomatic benign liver lesions. In all, 251 resections were performed in 240 (39% of all referred) patients during 1997–2002. From these, 48 (20% of all resected) patients had 'extended' (right or left) major hepatectomies, 51 (21%) patients had anatomical (right or left) hemi-hepatectomies, 17 patients (7%) underwent hilar or 'central' resections and the rest (52%) had segmental (single or multiple bilobar) resections. In addition, 12 patients had pre-operative portal vein embolisation to allow hypertrophy of the left lobe to minimise liver failure postoperatively, and 11 patients had repeat resections for hepatic recurrences. The overall in-hospital mortality was 3.2%. The median hospital stay was 11 days of which 3 days were spent on the high dependency unit (HDU). Of the patients, 137 (57%) did not require a peri-operative blood transfusion.

Resection rates

The geographical distribution of the operated patients was broadly in line with the distribution of referrals. Overall operation rates per head of population were markedly higher in people living in Sheffield than for people coming from the rest of the North Trent area.

In 2001, the rate of liver resection for colorectal cancer metastases in Sheffield was 3.8 procedures per 100,000 population while that for the rest of North Trent was 0.98 per 100,000. There has been a similar differential increase in the uptake of other hepatobiliary procedures with the rate for residents of Sheffield in 2001 being 3.2 per 100,000 and in the rest of North Trent 0.5 per 100,000.

Discussion

Primary colorectal cancer is the second most common malignant tumour in the UK, with an annual incidence of approximately 29,000 new cases each year,⁶ and as many

Table 1 Geographical distribution of referrals

Health authority	Population ^a	Number of patients referred
Sheffield	529,300	294
North Derbyshire	368,900	65
Rotherham	254,900	56
Barnsley	224,400	72
Doncaster	293,300	54
North Nottinghamshire ^b	391,000	19
Others		55

^aOffice of National Statistics (UK). Mid-2000 Population Estimates. Series PE(NO 3). HMSO 2001.

^bBassetlaw Hospital Workstop only.

as 15,000 patients die of colorectal carcinoma in this country each year.⁷ The liver is the most common site of secondary spread from this type of tumour.

The incidence of colorectal cancer has been recorded at 54.8 per 100,000 population per annum for the Trent region during 1992–1994. This level of incidence fits well with nationally reported rates of 59.5 per 100,000 (male) and 56.3 per 100,000 (female). Approximately 25% of colorectal patients will present with liver metastases diagnosed at the same time as the primary tumour (synchronous cases) while 25–50% of patients will develop liver metastases some time after the primary surgery, typically within a 2-year period (metachronous cases). This equates to an estimated incidence of people with liver metastases from colorectal cancer of around 40 per 100,000 per year. The North Trent health area has a population of approximately 1.5 million and about 600 patients would, therefore, be expected to develop liver metastases. Opinion differs on the proportion of patients who are likely to be regarded as suitable for surgery. Our experience suggests that, overall, at least 10% of these patients would meet our existing criteria – or about 4 patients per 100,000 population per year. This would equate to approximately 22 patients for the population of Sheffield and about 60 patients for the rest of North Trent (Table 1)

In the years before the establishment of the Sheffield service in 1997, only 5–7 patients per year underwent liver resection for colorectal metastases in the North Trent area. In 2001, the figure was 35 (a 7-fold increase). However, there appear to be marked differences in the uptake of the treatment across this area. While current operation rates for Sheffield are now around 3.8 per 100,000 per year (close to predicted figures based on the incidence of colorectal metastases), operation rates for the rest of our catchment area are currently still only 25% of this (0.98 per 100,000 population per year). Although the trend in hepatobiliary operation rates for residents of Sheffield has continued to rise over the 5 years, analysis of more recent data suggests that the incidence of complex hepatobiliary procedures for Sheffield residents may be approaching the maximum (Table 2)

Table 2 Number of referrals during the three phases of development

	Year		
	1996–7	1998–9	2000–1
Total referrals	57	187	324
Patients with colorectal metastases	26	117	185
Other hepatobiliary conditions	29	70	139

It is likely that the establishment of colorectal multi-disciplinary teams and increasing awareness of the effectiveness of hepatic resection in the treatment of colorectal liver metastases has had an impact in achieving these figures.⁸ It is useful to note that while surgical resection of other gastrointestinal cancers is commonly performed in the UK and accepted as standard treatment, the survival rates for these cancers can be considerably lower than those for patients undergoing hepatectomy for colorectal metastases. For example, patients undergoing pancreatoduodenectomy for pancreatic cancer¹² or oesophagectomy for oesophageal cancer¹³ have a mean 5-year survival of 10% and 20%, respectively, at best.

Staging of liver metastases from colorectal cancer and determination of resectability have been the subject of much recent debate.⁹ There is agreement that patients with evidence of extrahepatic disease should not undergo hepatic resection because there is no evidence that it improves survival.^{14,15} Despite careful pre-operative imaging, approximately 6% of patients with colorectal metastases in our series were found to have extrahepatic disease at the time of laparotomy. We have not used routine diagnostic laparoscopy in our patients as yet (due to the scheduling problems this extra surgical procedure would cause, as well as reduced sensitivity caused by the presence of adhesions from previous colonic surgery), although there is some evidence that it may reduce the number of 'open and close' laparotomies.¹⁶ There is no evidence that the size, number or distribution of metastases within the liver affects the overall outcome if they can all be resected in a single stage with clear margins^{17,18} (although two stage hepatectomies have recently been reported with good results¹⁹).

There is uncertainty regarding patients with an unknown primary who present with liver metastases. We believe that young and fit patients should undergo luminal gastrointestinal endoscopy or imaging; if a colorectal cancer is found, the primary and metastatic disease should be treated on merit. If a bowel primary is not found, a percutaneous biopsy of the liver metastases should be performed to exclude a treatable condition (*e.g.* lymphoma).

Accumulating data on hepatic resection for metastases in patients with known non-colorectal primary tumours suggest that hepatic resection should be offered if the primary tumour has been adequately treated, the liver is the only site of secondary involvement and a safe resection with clear margins is achievable.^{20–23}

Table 3 Trends in hepatobiliary procedures carried out at the Sheffield specialist hepatobiliary unit for residents of Sheffield and the rest of the North Trent area 1997–2001

	Sheffield Population 529,300				Rest of the North Trent area Population 1,532,500			
	Hepatic resection for colorectal cancer metastases		Other hepatobiliary operations		Hepatic resection for colorectal cancer metastases		Other hepatobiliary operations	
	Number	Rate per 100,000	Number	Rate per 100,000	Number	Rate per 100,000	Number	Rate per 100,000
1997	10	1.9	2	0.4	9	0.6	0	0
1998	14	2.6	3	0.6	9	0.6	1	0.1
1999	11	2.1	9	1.7	16	1	9	0.6
2000	16	3	3	0.6	16	1	11	0.7
2001	20	3.8	17	3.2	15	0.98	7	0.5

Rest of North Trent area includes the districts of Barnsley, Doncaster, North Derbyshire, North Nottinghamshire and Rotherham.

Recent advances in surgical resection of hilar cholangio-carcinoma allow access for potentially curative resections of high lesions.^{24–26} These resections can be combined with a left or right hemihepatectomy,²⁷ which allows access to the hilum and anastomoses of a roux loop to second, or third order bile ducts can be safely performed.

Economic evidence for liver resection

Rationing of resources is an important aspect of health funding in the UK and after the Sheffield service was established, there was considerable debate and initial reticence on the part of the local health authorities to fund this treatment long-term without evidence of cost-effectiveness. A joint project was commissioned by the Sheffield Health Authority with the School of Health and Related Research (SCHARR) to provide the economic evidence for cost effectiveness of hepatic resection in the treatment of colorectal liver metastases. This document⁴ and a subsequent publication in the *Annals of Surgery*²⁸ concluded that for suitable patients, hepatic resection is significantly more cost-effective than palliative chemotherapy. In addition, hepatic resection prolongs survival in up to 40% of these patients.¹⁷ This equates to an estimated cost per quality adjusted life year gained of liver resection for colorectal cancer in suitable patients of around £6000⁴ which is well below the currently accepted threshold of funding of £20,000 per life year gained.

Manpower and resource implications

The number of procedures carried out is dependent on the criteria for referral to the service and the criteria for selection of patients for operation. The criteria for selection for operation have remained constant throughout the last 4 years, while the criteria for referral by secondary care consultants may have altered with increased awareness. At present, there is a high degree of consistency in terms of referral practice within Sheffield

and the number of referrals is not expected to increase greatly from its present level. The pattern is less consistent elsewhere and there is obvious potential for the referral rates to rise to this level. These issues are currently being addressed through the local cancer network.

If it is assumed that the current procedure rate in Sheffield is close to the maximum level (*i.e.* all patients who meet the criteria are in fact being referred and operated on) then it may be possible to draw some conclusions about the eventual resource requirements to achieve consistent service across the catchment area.

In Sheffield, operation rates for colorectal metastases are currently running at about 4 per 100,000 population per year and other complex hepatobiliary procedures are currently running at a rate of 4 per 100,000 population per year giving a total 'need' of 8 procedures per 100,000 population per year. This figure is likely to be an underestimate and future projections may depend on selection criteria for surgery and may lead to a higher operation rate per head of population (Table 3).

Each complex hepatobiliary procedure requires a full operating list (usually one half-day). Current employment practice for NHS surgeons in the UK allows for 3 half-day operating surgery sessions per week. Assuming a pattern of 2 sessions dedicated to tertiary hepatobiliary surgery and 1 session to 'general' surgery and about 45 active weeks a year, a typical hepatobiliary specialist could potentially perform about 90 liver resections or similar procedures per year – covering the estimated need for these procedures for a population of about 1 million. The main infrastructure costs in addition to a standard operating theatre are the provision of surgical equipment (including ultrasonic dissectors) and intra-operative ultrasound scanning. In Sheffield, the average has been 3 days in the HDU and four such procedures are carried out each week (by two surgeons) would require at least four dedicated high dependency beds to support the service. These would be in addition to the availability of pre-operative and post-HDU ward-based care.

Overview of resource requirements

In practice, it would be desirable if such services could be located in centres serving populations of approximately 2 million to allow the employment of at least two specialist surgeons in order to rationalise the use of ancillary resources. Possibly, consideration could be given to locating them in centres serving 5–6 million people, but the high prevalence of colorectal cancer in our population would require patients to travel large distances to obtain treatment. For the current population in England and Wales, this would mean 25 specialist hepatobiliary centres performing in total approximately 2000 hepatic resections for colorectal cancer metastases and 2000 other tertiary hepatobiliary procedures (plus a certain amount of general surgery) each year. This would allow the provision of evenly distributed care with easy access to patients and facilitate their investigation, treatment and follow-up. Restricting the provision of these services to four or five large centres might disadvantage patients living peripherally to these centres.

Conclusions

We have described the development of a focused hepatobiliary resection programme in Sheffield and have demonstrated that with adequate expertise, equipment and facilities for postoperative care, even complex and major resections can be performed with low mortality and morbidity. These outcomes allow for a strong case to be made for the development of such programmes across the UK and we have provided guideline minimum figures for resource provision based on our experience.

References

- Association of Upper Gastrointestinal Surgeons (UK). *Discussion document on the provision of upper gastrointestinal surgery in the UK*. 1999.
- Neoptolemos JP *et al*. Low mortality following resection for pancreatic and periampullary tumours in 1026 patients. UK survey of specialist pancreatic units. UK Pancreatic Cancer Group [see comments]. *Br J Surg* 1997; **84**: 1370–6.
- Swisher SG, Deford L, Merriman KW, Walsh GL, Smythe R, Vaporician A *et al*. Effect of operative volume on morbidity, mortality, and hospital use after esophagectomy for cancer. *J Thorac Cardiovasc Surg* 2000; **119**: 1126–32.
- NHS Executive. *Improving outcomes in upper gastrointestinal cancer*. Guidance on Commissioning Cancer Services. NHS Executive (UK), 2001.
- Beard SM, Holmes M, Majeed A, Price C. *Hepatic resection as a treatment for liver metastases in colorectal cancer*. Trent Institute for Health Services Research, Universities of Leicester, Nottingham and Sheffield. Guidance note for purchasers 99/02, 1999.
- Zavadasky KE, Lee YT. Liver metastases from colorectal carcinoma: incidence, resectability and survival results. *Am Surg* 1994; **60**: 929–33.
- Bismuth H. Surgical anatomy and anatomical surgery of the liver. *World J Surg*. 1982; **6**: 3–9.
- The Office of National Statistics (UK). *Cancer Statistics Registrations – 1992*. Series MB1 no. 25. London: HMSO, 1998.
- The Office of National Statistics (UK). *Mortality Statistics: Cause – 1997*. Series DH2 no. 24. London: HMSO, 1998.
- Wigmore SJ, Madhavan K, Currie EJ, Bartolo DC, Garden OJ. Does the subspecialty of the surgeon performing primary colonic resection influence the outcome of patients with hepatic metastases referred for resection? *Ann Surg* 1999; **230**: 759–651, discussion 765–6.
- Nordlinger B, Guiguet M, Valliant JC, Balladur P, Boudjema K, Bachellier P, *et al*. Surgical resection of colorectal carcinoma metastases to the liver. A prognostic scoring system to improve case selection, based on 1568 patients. *Association Française de Chirurgie, Cancer* 1996; **77**: 1254–62.
- Scheele J, Stang R, Altendorf-Hofmann A, Paul M. Resection of colorectal liver metastases. *World J Surg* 1995; **19**: 59–71.
- Gayowski TJ, Iwatsuki S, Madarianga JR, Selby R, Todo S, Irish W *et al*. Experience in hepatic resection for metastatic colorectal cancer: analysis of clinical and pathologic risk factors [see comments]. *Surgery* 1994; **116**: 703–10, discussion 710–1.
- Hugh TJ, Kinsella AR, Poston GJ. Management strategies for colorectal liver metastases – Part 1. *Surg Oncol* 1997; **6**: 19–30.
- Rahusen FD, Cuesta MA, Borgstein PJ, Bleichrodt RP, Barkhof F, Doesburg T *et al*. Selection of patients for resection of colorectal metastases to the liver using diagnostic laparoscopy and laparoscopic ultrasonography. *Ann Surg* 1999; **230**: 31–7.
- Taylor M, Forster J, Langer B, Taylor BR, Greig PD, Mahut C. A study of prognostic factors for hepatic resection for colorectal metastases. *Am J Surg* 1997; **173**: 467–71.
- Scheele J, Altendorf-Hofmann A, Stangl R, Schmidt K. [Surgical resection of colorectal liver metastases: gold standard for solitary and radically resectable lesions]. *Swiss Surg* 1996; **Suppl 4**: 4–17.
- Berney T, Mentha G, Roth AD, Morel P. Results of surgical resection of liver metastases from non-colorectal primaries. *Br J Surg* 1998; **85**: 1423–7.
- Hamy AP, Paineau JR, Miralle EC, Bizouan P, Visset JP. Hepatic resections for non-colorectal metastases: forty resections in 35 patients. *Hepatogastroenterology* 2000; **47**: 1090–4.
- Lang H, Nussbaum KT, Weimann A, Raab R. [Liver resection for non-colorectal, non-neuroendocrine hepatic metastases]. *Chirurg* 1999; **70**: 439–46.
- Seifert JK, Junginger T. [Liver resections of metastases of non-colorectal primary tumors]. *Chirurg* 1996; **67**: 161–8.
- Miyazaki M, Ito H, Nakagawa K, Ambiru S, Shimizu H, Okaya T *et al*. Parenchyma-preserving hepatectomy in the surgical treatment of hilar cholangiocarcinoma. *J Am Coll Surg* 1999; **189**: 575–83.
- Kosuge T, Yamamoto J, Shimada K, Yamasaki S, Makuuchi M. Improved surgical results for hilar cholangiocarcinoma with procedures including major hepatic resection. *Ann Surg* 1999; **230**: 663–71.
- Valverde A, Bonhomme N, Farges O, Sauvanet A, Flejou JF, Beghiti J. Resection of intrahepatic cholangiocarcinoma: a Western experience. *J Hepatobil Pancreat Surg* 1999; **6**: 122–7.
- Neuhaus P, Jonas S, Bechstein WO, Lohmann R, Radke C, Kling N *et al*. Extended resections for hilar cholangiocarcinoma. *Ann Surg* 1999; **230**: 808–18, discussion 819.
- Adam R, Laurent A, Azoulay D, Castaing D, Bismuth H. Two-stage hepatectomy: a planned strategy to treat irresectable liver tumors. *Ann Surg* 2000; **232**: 777–85.
- Hunt TM, Carty N, Johnson CD. Resection of liver metastases from colorectal carcinoma does not benefit the patient. *Ann R Coll Surg Engl* 1990; **72**: 199–205.
- Reber HA, Ashley SW, McFadden D. Curative treatment for pancreatic neoplasms. *Surg Clin North Am* 1995; **75**: 905–11.
- Lee RB, Miller JJ. Esophagectomy for cancer. *Surg Clin North Am* 1997; **77**: 1169–96.
- Beard SM, Holmes M, Price C, Majeed AW. Hepatic resection for colorectal metastases in Sheffield (1997–1999): a cost-effectiveness analysis. *Ann Surg* 2000; **232**: 763–76.