Laparoscopic Ultrasound in Staging of GI Malignancies

10

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Introduction

Surgical resection is the treatment of choice for most GI malignancies. Whether resection with curative intent is possible will be determined by the stage of the malignancy. Staging is the process by which the primary malignancy is assessed and its degree of progression beyond the site of origin determined. Of particular importance is the presence of local invasion, lymph node metastases and metastases to distant organs.

The accuracy by which the stage of a GI malignancy can be determined prior to resection has greatly improved in recent years, directly as a result of advances in diagnostic imaging. Computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET-CT) and endoscopic ultrasound (EUS) are now widely employed in the assessment of malignancy and planning of treatment. Despite improvements in the spatial resolution of cross-sectional imaging modalities, these remain relatively poor in determining the presence of peritoneal disease, and all have limitations in the assessment of local progression.

Staging laparoscopy is a quick, safe, but invasive investigation with which the presence of peritoneal disease can be determined. It has few disadvantages and can avoid an unnecessary nontherapeutic laparotomy. Critics of the technique complain that its accuracy is low, that it is an additional procedure and that it ignores the possibility of palliative surgery. The addition of direct contact laparoscopic ultrasonography (LUS) provides the ability to further assess the local stage of disease and to evaluate the liver for metastases. Although laparoscopy is widely used in the assessment of many gastrointestinal malignancies, the indications and sensitivity/specificity of LUS in contemporary practice remain poorly defined. There are no randomised controlled trials of laparoscopy or LUS, and in many areas, the case series are small in size.

Principles of Laparoscopy for Staging

The clear benefit of laparoscopy over cross-sectional imaging is its ability to diagnose peritoneal disease that may not be apparent even on high-quality CT imaging.

There are three potential advantages of laparoscopy over cross-sectional imaging in the staging of GI malignancy:

1. The diagnosis of peritoneal disease
2. The determination of local resectability and formulation of an operative plan
3. The ability to obtain tissue for diagnosis

Technique

Laparoscopy

As with all laparoscopy, some thought should go into the operating room set-up to allow the surgical team to work comfortably (Fig. 10.1). High-definition (HD) camera systems are now common and provide excellent visualisation of the peritoneal cavity (Fig. 10.1a). The laparoscopic monitor and stack should be positioned beyond the patient in the direction the surgeon is working. The laparoscopic ultrasound monitor can be placed beside this. Although, in our practice, facilities are available for 'picture-in-picture' – the ultrasound monitor view being placed on the same screen as the laparoscopic image – this may obstruct the laparoscopic view. HD recordings of the laparoscopic camera feed can be undertaken, and facilities for recording video images of the ultrasonography are useful.

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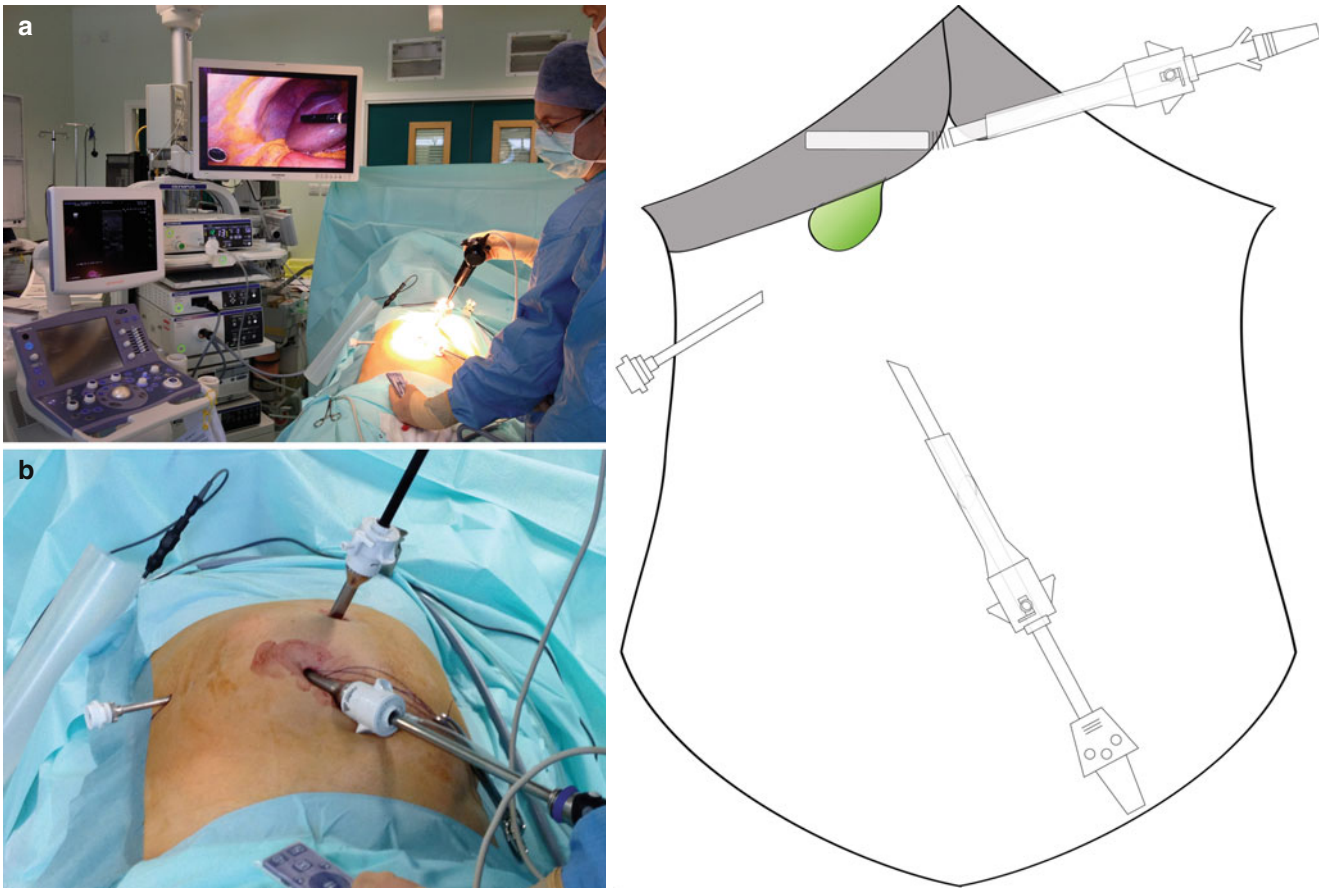

Fig. 10.1 Setting-up staging laparoscopy. The laparoscopic monitor is placed beyond the patient in the direction the surgeon is working (**a**). The laparoscopic ultrasound machine is placed to the left of this. An assistant is controlling the laparoscopic camera while the primary surgeon manipulates the ultrasound probe. Note the remote control unit for the ultrasound machine in the surgeon's left hand with which he is recording images and turning the Doppler flow on and off. There are many options for port placement and this is our preferred (**b**). A pneumoperitoneum is established through an infraumblical port inserted with an open technique. A further 10–12 mm port is placed in the epigastrium to the left of the midline and well below the costal margin. A 5 mm port for a grasper is placed in the right upper quadrant

There are a number of options for laparoscopic port placement, and this depends on the primary organ for investigation. Our standard approach (Fig. 10.1b, c) involves establishing a pneumoperitoneum (12 mmHg) via a 10 mm infraumbilical port placed under direct vision. A further 10 mm port is placed in the epigastrium to the left of the midline well below the costal margin. A 5 mm port is usually placed on the right side for use of a grasper. These positions allow easy access to the liver, gallbladder and portal pedicle. In the staging of oesophagogastric cancer, it can be preferable to place the 10–12 mm port on the right side of the abdomen and the 5 mm port on the left. The right-sided and umbilical ports can then be used to gain easy access to the stomach and oesophageal hiatus.

A 30° laparoscope is inserted through the umbilical port and a careful inspection of the intra-abdominal organs and peritoneum performed (Fig. 10.2a, b). Particular attention is paid to the falciform ligament, liver (including the under surface, Fig. 10.2a), diaphragm, hepatoduodenal ligament and lesser omentum. The greater omentum is retracted superiorly to allow the small bowel mesentery and ligament of Treitz to be directly visualised.

Laparoscopic Ultrasonography

A high-resolution flexible tip linear array transducer is inserted through the epigastric port (Fig. 10.2c). Systematic scanning of the liver should start with identification of standard landmarks and of the liver parenchyma. A window may be made in the falciform ligament to aid visualisation of the hepatic outflow. Intrahepatic liver metastasis can appear as hyper-, iso- or hypoechoic lesions on imaging. It can also be useful to position the probe on the underside of the liver, particularly on the right lobe (Fig. 10.2f). This manoeuvre can be used to better visualise lesions in the posterior section (segments VI/VII) of the liver.

Depending on the location of the primary tumour, identification of structures in the portal triad is now performed

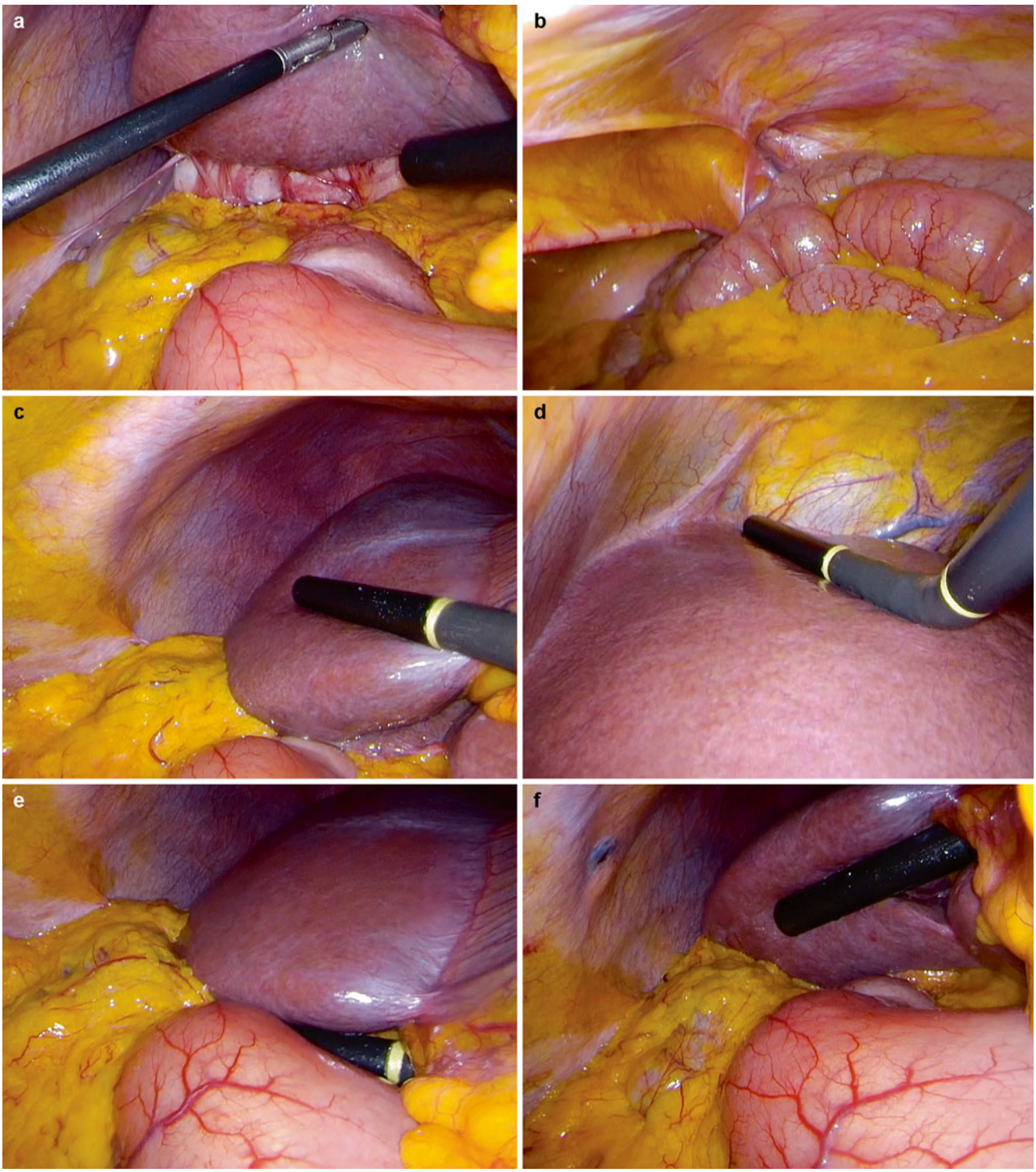

Fig. 10.2 Staging laparoscopy. Begin with a full inspection of the peritoneal cavity lifting the left and right liver to view the underside (**a**) and paying particular attention to the peritoneum (**b**). Use laparoscopic ultrasound to orientate on the origin of the left and right portal vein branches and carefully visualise the parenchyma of the right lobe (**c**). Look on the left side of the falciform ligament and scan segments II and III (**d**). Place the probe on the hepatoduodenal ligament in the transverse plane to examine the portal pedicle (**e**). The probe can also be placed on the underside of any part of the liver and orientated anteriorly (**f**). Adhesions around the gallbladder can be seen as a result of recent acute cholecystitis (**a**)

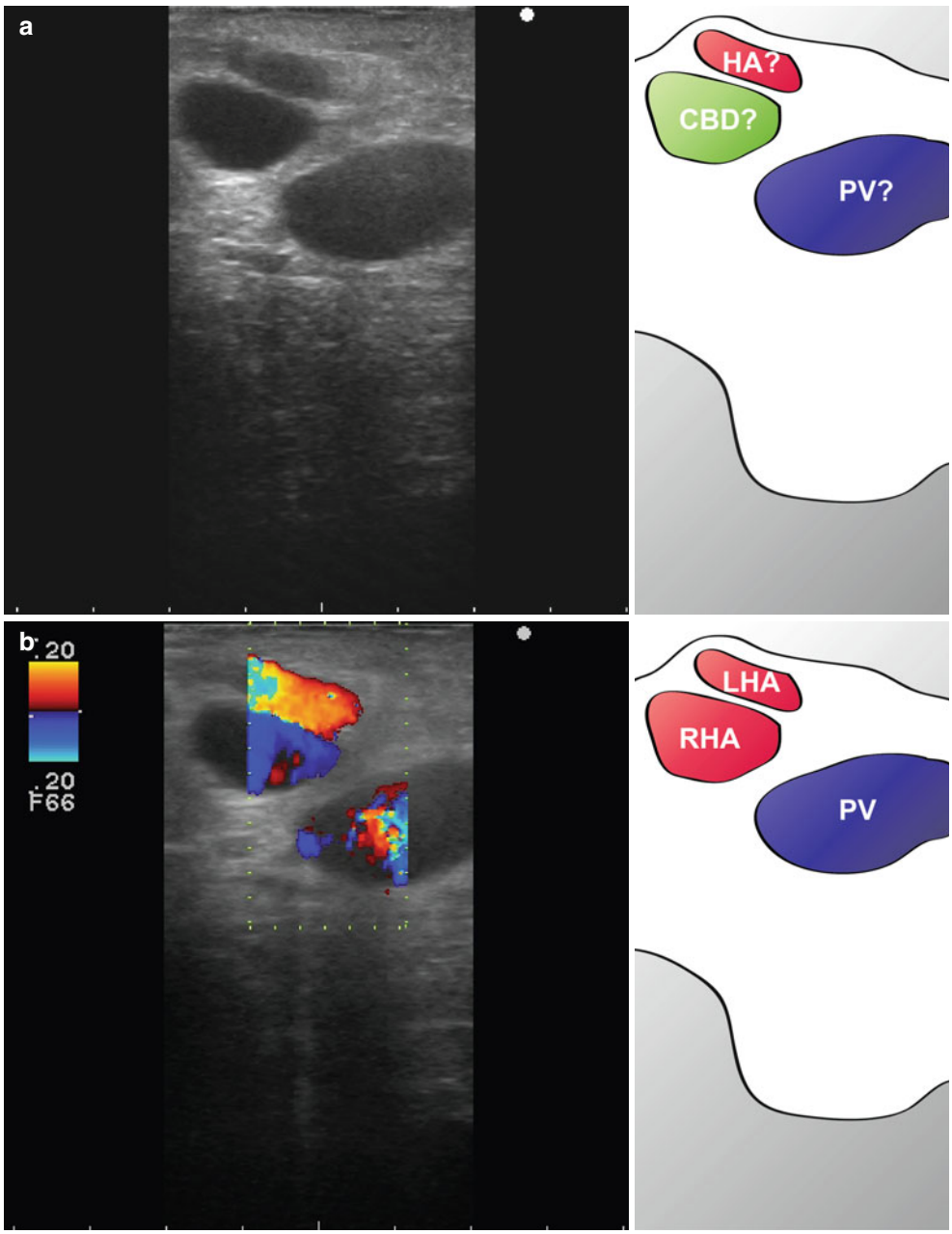

Fig. 10.3 Colour flow Doppler in the identification of structures. Three structures are apparent in the hepatoduodenal ligament (**a**). These appear to have the configuration of the portal vein (*?PV*), hepatic artery (*?HA*) and bile duct (*?CBD*) (see Chap. 14). However, when colour flow Doppler is used, it is apparent that all three structures (*LHA* left hepatic artery, *RHA* right hepatic artery, *PV* portal vein) are blood vessels (**b**). In this patient, the hepatic artery bifurcates early, and the bile duct was small and lateral. Colour flow was useful in differentiating the bile duct from the artery

(Fig. 10.2e). Visualisation of the portal structures can be aided by inserting the probe through the infraumbilical port and placing it on the hepatoduodenal ligament (see Chap. 14 for further information). By identifying the inferior vena cava posteriorly and rotating the probe counterclockwise, the portal vein, bile duct and hepatic artery are visualised. The portal vein can be followed to the splenoportal confluence and continued down the superior mesenteric vein. This manoeuvre is clearly important in tumours of the head of pancreas and distal common bile duct.

Vascular invasion is suggested by the absence of the tissue plane between the tumour and blood vessel. Avoid excessive pressure with the probe as this can emulate the appearance of tumour involvement into vessels when this has not occurred. The presence of a fixed stenosis in a vessel in more than one plane suggests tumour involvement. If views are not adequate due to poor probe contact or as a result of the pneumoperitoneum, CO_2 can be released and saline injected into the peritoneum to improve probe contact, though is rarely required.

In pancreas and biliary tumours, the primary lesion should be assessed to determine the proximal and distal extent, radial extension (particularly arterial and venous invasion) and the presence of lymph node metastases. Lymph nodes invaded by tumour are hypoechoic with a loss of definition. While enlarged lymph nodes may represent the presence of

metastatic disease, this finding is non-specific and should be confirmed pathologically (Fig. 14.4b, c).

Careful examination should be made of the coeliac trunk and aortocaval window for suspicious nodes. Large coeliac trunk nodes can sometimes be accessed through the less omentum and biopsy made. Care needs to be taken to avoid bleeding in this area. Colour Doppler can be helpful in differentiating vessels from nodes during these manoeuvres (Fig. 10.3).

Laparoscopic Biopsy

A patient presenting with painless obstructive jaundice and a mass in the head of pancreas on CT underwent staging laparoscopy (Fig. 10.4). A full staging laparoscopy was performed followed by laparoscopic ultrasound through an epigastric port (Fig. 10.4a, b). Suspicious lesions were seen in segment II/III (Fig. 10.4a, c) and segment V (Fig. 10.4b, d) of the liver. These were firm on direct pressure with a grasper and had a 'target' appearance on ultrasonography suggesting metastatic disease.

Any suspicious lesions identified can then be biopsied directly or using ultrasound guidance. The lesion in segment II/III was accessible and biopsied directly using scissors (Fig. 10.5). It is best not to use diathermy when taking the biopsy to avoid thermal artefact, particularly when the specimen is small. Bleeding can be controlled with diathermy after the specimen is removed (Fig. 10.5f). In this case, the biopsy was sent for direct frozen-section analysis and adenocarcinoma was confirmed.

Oesophagogastric Junctional Cancer and Gastric Cancer

The epidemiology of gastric cancer has altered over the last 40 years. The site of origin within the stomach has changed in frequency in the USA and Europe, with a reduction in the incidence of cancer arising in the distal half of the stomach and a rapid increase in the number of cases of the cardia and gastro-oesophageal junction [1]. The overall incidence of cancer at these sites has also risen rapidly, especially in patients younger than 40 years.

The prognosis of patients with these cancers is related to local tumour extent, including both nodal involvement and direct tumour extension beyond the gastric wall [2]. Importantly, the presence of metastases in the peritoneal cavity or distant organs renders the disease incurable and the prognosis is usually very poor. Following resection, the peritoneum is the most common site of recurrence as a result of malignant cells shed from the primary tumour [3].

Radical surgical resection is the only curative treatment for patients with oesophagogastric cancers and is the first-choice treatment in patients with early-stage disease [4]. However, the majority of patients have advanced disease at the time of diagnosis, and accurate preoperative staging is essential to guide management. The objectives of cancer staging are to confirm the diagnosis of malignancy and to determine the extent of the disease, enabling the most appropriate treatment modality to be selected [5]. Given that radical surgery provides the only curative treatment of oesophagogastric cancer, the number of falsely over-staged patients must be minimised to ensure that the possibility for cure is not missed. Yet the sensitivity of any test measuring dissemination of oesophagogastric cancer must be high to avoid unnecessary explorative laparotomies. It has been widely shown that despite improvements in quality, CT still has a low sensitivity for detecting peritoneal disease, hence the proposed need for laparoscopic staging [6].

High-quality contrast-enhanced computerised tomography is the most accurate, widely used, non-invasive modality for detecting distant metastases in oesophagogastric cancer [7]. The introduction of endoscopic ultrasound (EUS) has also been successful in improving the accuracy of preoperative staging in oesophagogastric cancers and is more accurate than CT in determining T and N stages [8] (see Chap. 11 for further information). An added benefit of EUS is the ability to sample suspicious lymph nodes using needle aspiration/mini-core biopsy. As in other diseases described here, CT is inaccurate in the evaluation of peritoneal disease, with sensitivity ranging from 30 to 73 % and specificity from 83 to 100 % [9].

A number of small observational studies have been published comparing imaging modalities in the staging of oesophagogastric cancer. In a study from the authors' own centre, LUS was compared with CT and EUS. Thirty-six patients with histologically proven carcinoma of the oesophagus or stomach who were considered fit for surgery underwent CT, EUS and LUS. The findings of these investigations were compared with final histopathology or intraoperative findings where the tumour was irresectable. Locally advanced tumours were accurately identified by CT in 15/16 (94 %), EUS in 14/16 (88 %) and LUS in 10/12 (83 %). In the assessment of locoregional lymph node involvement, EUS was superior to both CT and LUS: accuracy 21/29 (72 %) versus 17/29 (59 %) and 17/29 (59 %). Although the specificity of LUS in assessment of lymph node involvement was good compared to CT and EUS, the sensitivity was poor: sensitivity/specificity, EUS 79 %/60 %, CT 68 %/40 % and LUS 42 %/90 %. LUS was clearly superior in the identification of metastatic disease, with an accuracy of 21/32 (81 %) versus 23/32 (72 %) for CT. The authors concluded that although the numbers were small, CT, EUS and LUS act in a complimentary manner to provide the most complete preoperative staging for patients with oesophagogastric cancer [10].

In an earlier study aiming to determine the added benefit of LUS over laparoscopy, of 93 patients who underwent

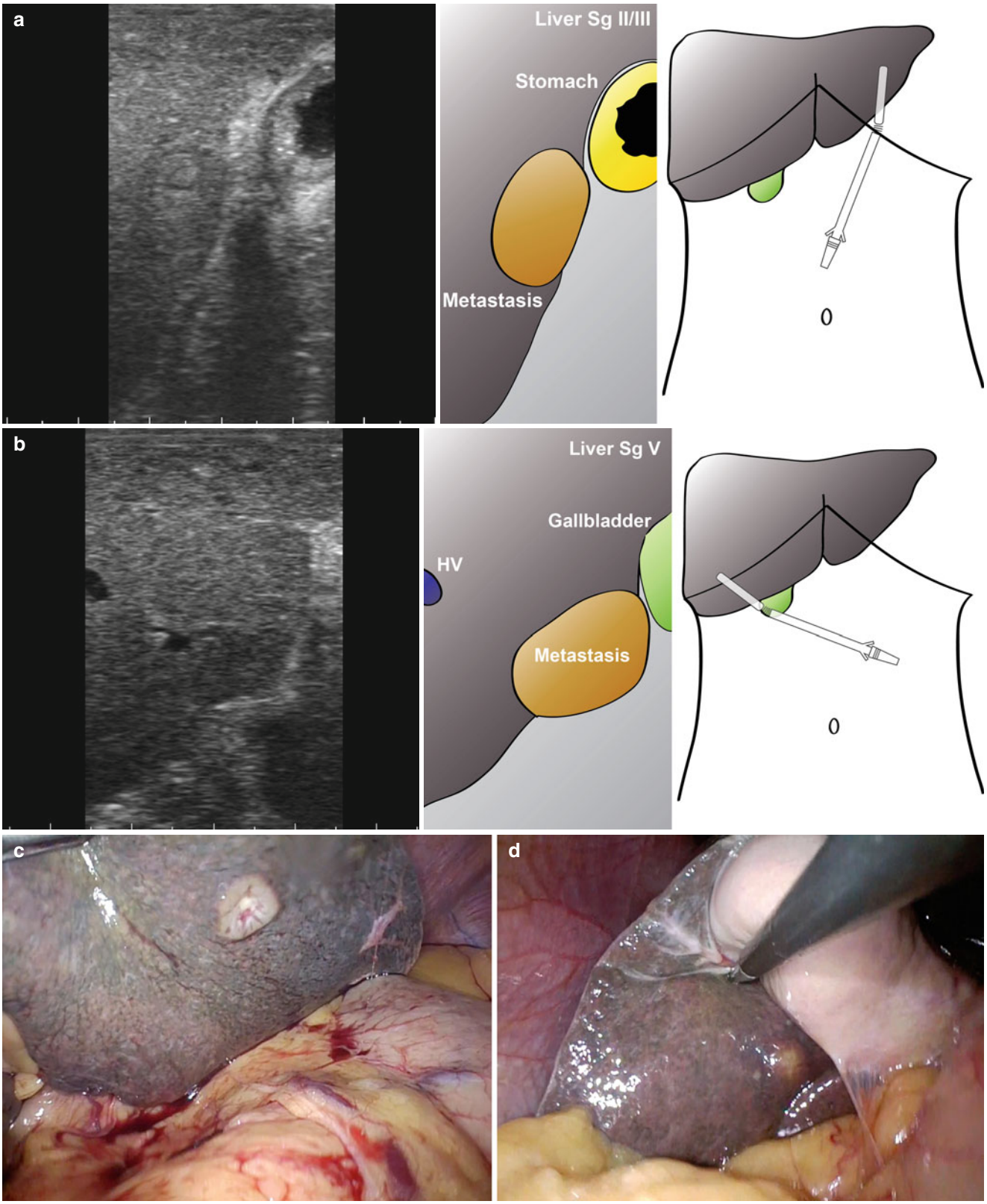

Fig. 10.4 Staging laparoscopy in a patient with a head of pancreas mass. A small lesion had been seen in the right liver on CT and MRI but was too small to characterise. At laparoscopy a lesion was seen in segment II/III of the liver (**a**, **c**) and segment V (**b**, **d**). These looked suspicious and on biopsy with frozen-section analysis, the left-sided lesion was confirmed to be adenocarcinoma (**c**)

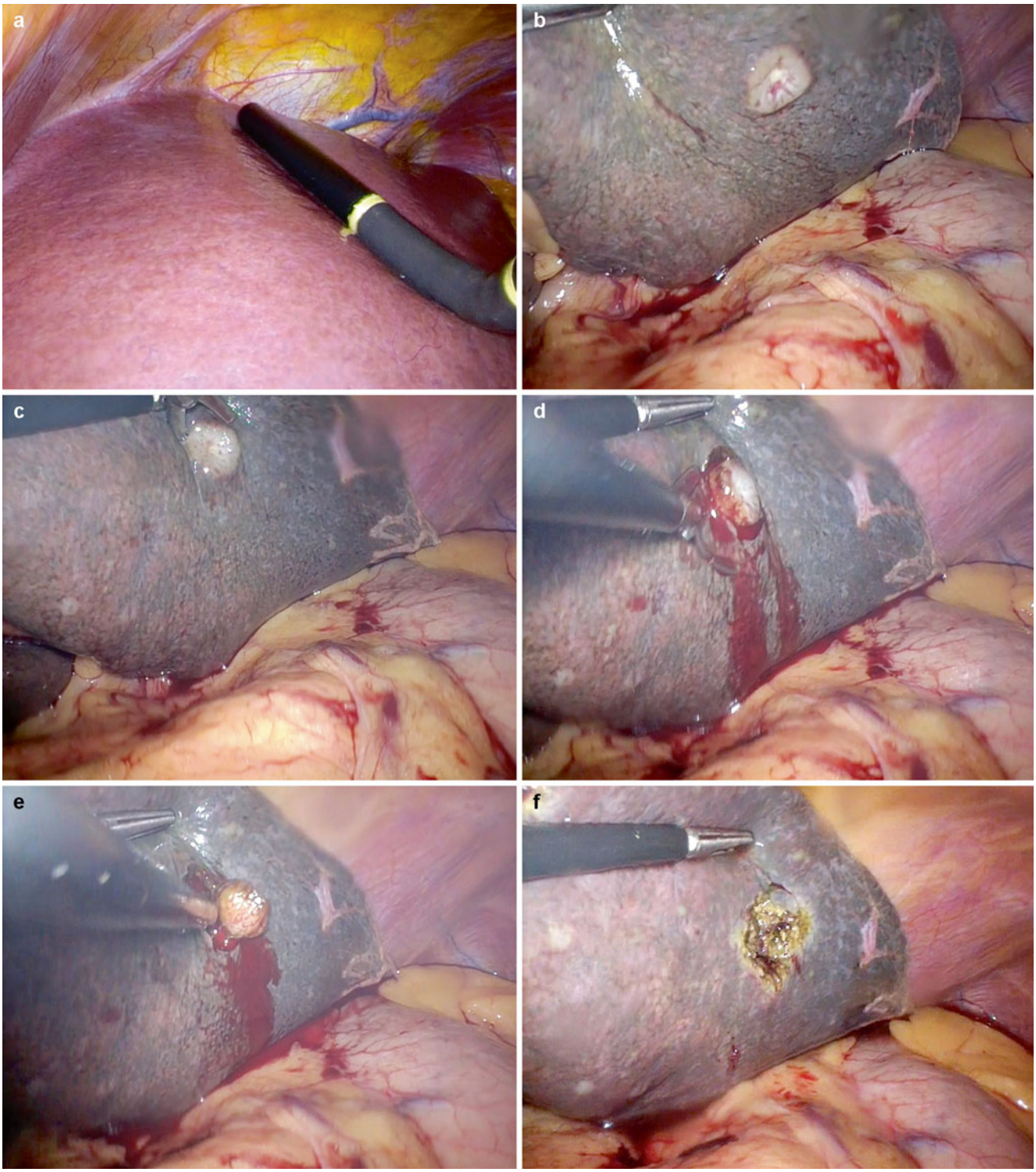

Fig. 10.5 Laparoscopic ultrasound and biopsy of suspicious liver lesion in a patient with head of pancreas mass. The lesion is identified with the ultrasound (**a**) and visualised (**b**). Using scissors without diathermy (**c**), the lesion is excised and subjected to frozen-section analysis (**d**, **e**). Diathermy is used to achieve haemostasis (**f**)

laparoscopy, 18/93 (19.4 %) were shown to have irresectable disease and avoided an inappropriate laparotomy. With the addition of LUS, a further 7/93 (7.5 %) were found to have advanced disease [11]. The unnecessary laparotomy rate reduced from 5/25 (20 %) in those without laparoscopy to 9/75 (12 %) with laparoscopy and 2/68 (3 %) in those who

had LUS. These findings suggesting a positive role for LUS in the staging of OG malignancy were mirrored in other studies [12–15]. However, more recent studies have shown less benefit with the addition of LUS to laparoscopy, possibly as a result of the improved quality of CT and EUS.

In one such study comparing CT, transabdominal ultrasound, laparoscopy and LUS in the assessment of 47 patients with gastric cancer, laparoscopy was accurate in determining overall clinical stage (31/37, 84 %) compared with transabdominal ultrasound (20/37, 54 %) and CT (23/37, 62 %) [6]. However, the addition of laparoscopic ultrasonography did not change the stage of the disease or the decision of whether to proceed with laparotomy for any of the patients, which was correctly predicted in 95 % of the cases. Laparoscopy was superior for detecting peritoneal seeding and ascites, characteristic features of advanced gastric carcinoma. Laparoscopy was also superior in identifying local extension of gastric carcinoma, but the additional information from LUS was minor. The lack of benefit with LUS was also seen in another smaller study, which looked at 18 patients [16].

One of the advantages of staging laparoscopy is the ability to sample tissues. Specifically in gastric cancer, the use of peritoneal lavage cytology can be used to determine operability. In this procedure, fluid is instilled in the upper abdominal cavity at laparoscopy, aspirated and spun-down for cytological examination. In a study examining the value of this procedure in oesophagogastric adenocarcinoma, 255 patients had peritoneal washings at laparoscopy of which 48/255 (18.8 %) had overt peritoneal metastases at staging laparoscopy. Of the remaining patients, 15/207 (7.2 %) had positive cytology. These patients had a median (95 % confidence interval) survival of 13 (3.1–22.9) months versus 9 (7.4–10.6) months for those with overt peritoneal metastases ($p=0.517$). The authors conclude that positive peritoneal cytology in the absence of overt peritoneal metastases was a marker of poor prognosis and should be considered to signify incurable disease [17].

Overall, laparoscopy increases the demonstrated disease stage in 40 % of gastric cancer patients and avoids unnecessary laparotomy in around 25 % (Level II evidence) [18]. It has also been suggested that laparoscopy may downstage tumours thought to be T4 on EUS to T3 by demonstrating the absence of direct invasion into surrounding structures [18]. Early series showed the addition of LUS to be an advantage, but this has been questioned in more recent studies. While the requirement for staging laparoscopy with peritoneal washings is supported by the NCCN Clinical Practice Guidelines in the USA [19] and the SIGN guidelines in the UK [7], neither specifically recommend the use of LUS. The Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) guidelines conclude that LUS for gastric cancer staging can be performed safely and adds little time to the duration the procedure (Grade A). The routine use of staging laparoscopy and LUS after a negative preoperative workup is recommended (Grade B) [18].

Colorectal Liver Metastases

Colorectal cancer (CRC) is the third most common cancer worldwide and the second most frequent cause of cancer death in the USA [20]. The liver is the most frequent site of metastases, and liver resection and ablation are accepted as standard treatment strategies [21]. Outcomes after surgical management of colorectal liver metastases (CRLM) are improving, with 5-year survival now approaching 50 % [22]. Accurate preoperative staging is essential if treatments are to be targeted to those who will benefit most.

Factors associated with poor long-term outcome after liver resection for CRLM include positive margin (hazard ratio (HR) = 1.7, $p=0.004$), extrahepatic disease (HR = 1.7, $p=0.003$), node-positive primary (HR = 1.3, $p=0.02$), disease-free interval from primary to metastases < 12 months (HR = 1.3, $p=0.03$), number of hepatic tumours > 1 (HR = 1.5, $p=0.0004$), largest hepatic tumour > 5 cm (HR = 1.4, $p=0.01$) and carcinoembryonic antigen level > 200 ng/ml (HR = 1.5, $p=0.01$) [23].

Laparoscopy or LUS is not generally recommended for the staging of patients with CRC without evidence of CRLM. In patients with CRC and suspected or proven CRLM, US and European guidelines recommend staging with CT with intravenous contrast, positron emission tomography (PET) CT and/or MRI imaging [21, 24]. As the quality and resolution of these modalities improve, the role of laparoscopy and laparoscopic ultrasound in the staging of colorectal cancer becomes less clear.

The UK guidelines suggest that patients with 'high-risk' primary disease (T4 (perforated), C2 (apical node)) should have careful preoperative investigations that might include laparoscopy. Laparoscopy may identify occult metastatic disease and prevent unnecessary laparotomy in some patients with potentially resectable colorectal liver metastases, and LUS may provide additional information in selected patients [21]. Laparoscopy/LUS may also be useful in the presence of multiple bilobar disease when there are concerns regarding the feasibility of liver resection or imaging is indeterminate.

Conversely, Dutch guidelines for the management of CRLM state that there is no role for diagnostic laparoscopy in routine daily practice due to its invasiveness and the low prevalence of small subcapsular liver lesions and extrahepatic disease. Small liver metastases 'missed' on preoperative imaging also have less clinical consequence as these can generally be resected [25].

A recent meta-analysis examined the role of laparoscopy and laparoscopic ultrasound in the preoperative staging of patients with resectable colorectal liver metastases (Tables 10.1 and 10.2) [38]. The authors identified 12 studies that described a total of 1,047 patients who underwent staging laparoscopy and/or LUS. The difficulty in comparing studies of this type is the assessment of inclusion criteria for the diagnostic test. Significant heterogeneity exists between studies making data synthesis difficult. Clearly, older studies using low-resolution CT imaging are likely to have less

Table 10.1 Meta-analysis of studies examining the role of laparoscopy and laparoscopic ultrasound in the preoperative assessment of patients with resectable colorectal liver metastases: study characteristics

Study	Year	Country	Study type	Preoperative investigation	Patients, *n*	Median age, years	STARD score[a]
Biondi [26]	2010	Italy	Not defined	CT/MRI/PET	65	63	10
Muntean [27]	2009	Romania	Prospective	CT/MRI/PET	18	NA	13
Pilkington [28]	2007	England	Retrospective	CT/MRI	73	NA	12
Khan [29]	2007	England	Retrospective	CT/MRI	210	NA	8
Mann [30]	2007	England	Retrospective	CT/CEA/PET/MR	200	60	13
Mortensen [31]	2006	Denmark	Retrospective	CT	45	62	13
de Castro [32]	2004	The Netherlands	Prospective	US/CT/MR	43	NA	15
Koea [33]	2004	New Zealand	Prospective	CT/CEA	59	65	14
Metcalfe [34]	2003	Australia	Retrospective	CT/CEA	24	NA	12
Grobmyer [35]	2004	United States	Retrospective	CT/CEA/PET/MR	264	62	16
Gholghesaei [36]	2003	The Netherlands	Retrospective	CT/CEA/PET/MR	56	NA	16
Rahusen [37]	1999	The Netherlands	Not defined	CT/CEA/US/MR	50	61	14
Overall	–	–	–	–	1,107		–

Adapted from Hariharan et al. [38]

[a]The STARD statement is a 25-item checklist and recommends the use of a flow diagram, which describes the design of the study and flow of the patients

Table 10.2 Meta-analysis of studies examining the role of laparoscopy and laparoscopic ultrasound in the preoperative assessment of patients with resectable colorectal liver metastases: study results

Study	Lap	Lap/LUS	Sensitivity, %	Specificity, %	PPV, %	NPV, %	True yield, %
Biondi [26]	62	62	72.7 (54.50–86.70)	100	100	76.3	38.7
Muntean [27]	18	18	75.0 (19.4–99.40)	92.9 (66.10–99.80)	75	92.8	16.6
Pilkington [28]	73	73	69.6 (47.10–86.80)	100	100	87.7	21.9
Khan [29]	202	202	39.3 (21.50–59.40)	100	100	91.1	5.45
Mann [30]	178	178	61.9 (48.80–73.90)	100	100	82.7	21.9
Mortensen [31]	38	38	57.1 (18.40–90.10)	100	100	91.1	10.5
de Castro [32]	32	32	71.4 (29.00–96.30)	100	100	92.5	15.6
Koea [33]	54	41	37.5 (8.50–75.00)	100	100	90.2	7.3
Metcalfe [34]	24	24	66.7 (34.90–90.01)	100	100	75	33.3
Grobmyer [35]	264	168	41.3 (29.0–54.0)	100	100	84.4	15.4
Gholghesaei [36]	55	48	73.1 (52.50–88.40)	100	100	80.5	39.5
Rahusen [37]	47	47	75.0 (53.30–90.20)	100	100	79.3	38.3
Overall	1,047	931	59.1 (53.20–64.70)	99.9 (99.30–100)	99.4	86	18.90 (16.44–21.57)

Adapted from Hariharan et al. [38]

contemporary relevance, while trials using the best available cross-sectional imaging with tighter inclusion definitions are likely to demonstrate the greatest utility in laparoscopy, at the expense of the total proportions of their practice numbers included. None of the considered trials were randomised or blinded. The true yield of laparoscopy/LUS for CRLM was 19 % (95 % CI, 16–22 %) with an overall sensitivity of 59 % (95 % CI, 53–65 %). Subgroup analysis for detection of other liver and peritoneal lesions showed a sensitivity of 59 % (95 % CI, 49–67 %) and 75 % (95 % CI, 63–85 %), respectively.

The use of a clinical risk score (CRS) may be a valid method of identifying patients most likely to benefit from LUS. In a study of 79 patients, LUS prevented unnecessary laparotomy in 15/74 patients by predicting the benign nature of lesions or demonstrating unresectability [39]. A CRS was determined based on lymph node-status of primary tumour, disease-free interval, number of metastases, largest metastasis and CEA. In those with a CRS < 2, LUS prevented a laparotomy in only 7 % of patients. However, in those with a CRS > 2, LUS prevented an operation in 24 % of patients. The authors concluded that selecting those likely to benefit from LUS will increase the utility of the investigation.

The best indication for laparoscopy and laparoscopic ultrasound in CRLM is in patients with resectable disease, but a suspicion of peritoneal disease that is not well defined on cross-sectional imaging or PET-CT. This is with the intention of avoiding an unnecessary laparotomy in patients with extrahepatic disease. As laparoscopic liver resection becomes more common, this step will be part of the resection procedure anyway.

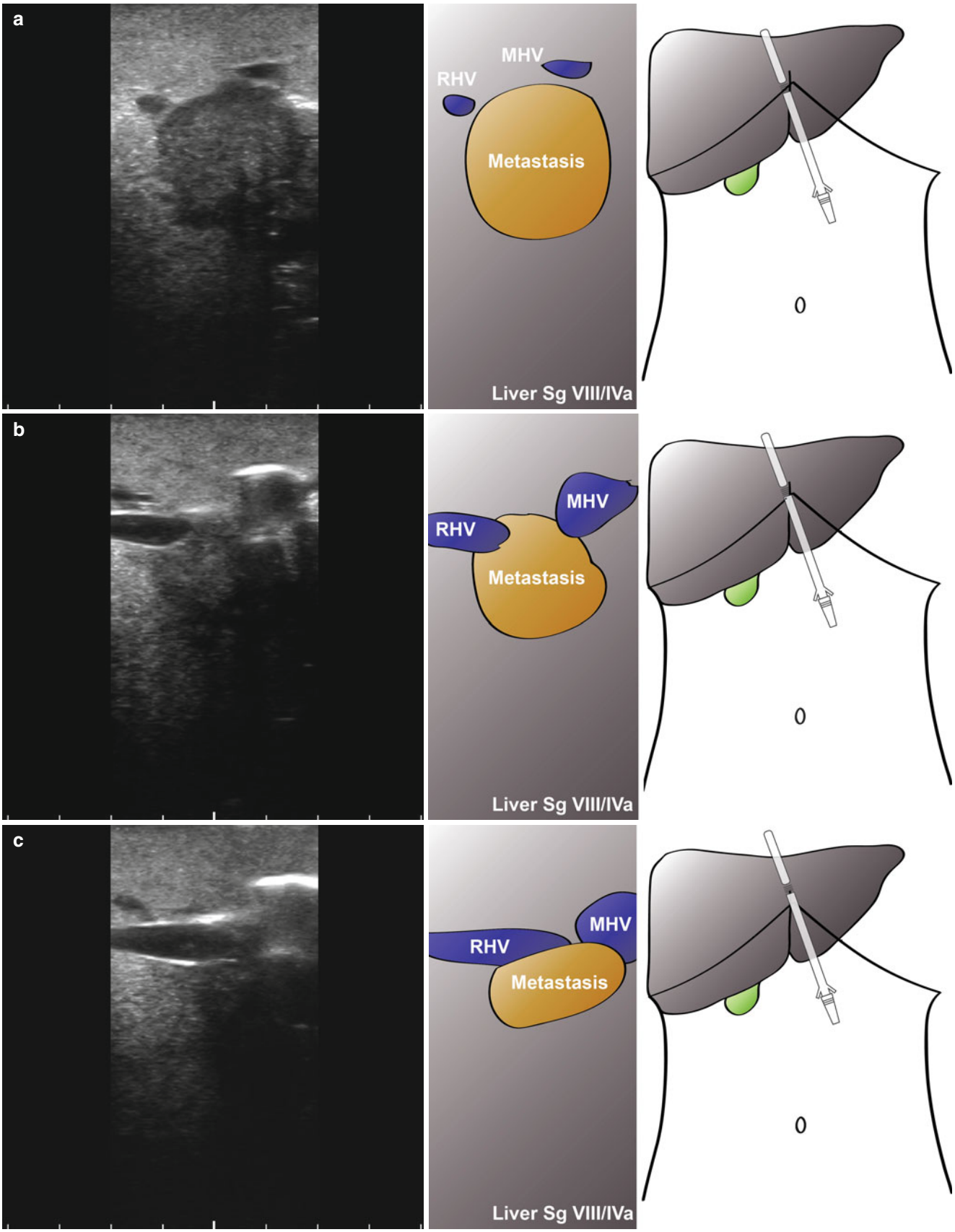

Fig. 10.6 Laparoscopic ultrasonography in a patient with large colorectal liver metastasis at the hepatic outflow (**a**; RHV, right hepatic vein; MHV, middle hepatic vein). As the probe is moved up towards the suprahepatic vena cava (**b**), a large metastasis can be seen sitting between the right and middle hepatic veins (**c**)

The final area in which LUS may be of use is in patients with borderline resectable disease. Figure 10.6 shows images from a patient with a colorectal liver metastasis high in segment VIII. A right hepatectomy was being considered, but significant progression of disease had occurred since the last cross-sectional imaging. LUS shows clear impingement of the metastasis upon the middle hepatic vein. The procedure was abandoned, and the patient had radiological embolisation to the right lobe and segment IV. A successful extended right hepatectomy was performed 6 weeks later. In a different case, local resection was being considered for a right-sided CRLM (Fig. 10.7). Again, there has been significant progression of disease and with ultrasonography clearly showing tumour abutting the segment VIII pedicle (Fig. 10.7a, b, Video 10.1) and indenting the right hepatic vein with possible invasion (Fig. 10.7c, d, Video 10.2). This patient went on to have a successful open right hepatectomy.

In summary, the ratio of patients benefiting from laparoscopy/LUS (i.e. those avoiding an unnecessary laparotomy) to those submitted to the procedure (the true yield) is around 20 %. It is likely that this could be increased by selecting the patients most likely to benefit. Ultrasound has a place in the assessment of borderline resectable disease, and the rise in the number of laparoscopic liver resections will naturally encourage an increased use in LUS assessment.

Hepatocellular Carcinoma

Hepatocellular carcinoma (HCC) is a leading cause of cancer-related death worldwide [40]. The incidence is particularly high in East Asia and sub-Saharan Africa and is rising in North America and Europe. Around 80 % of cases develop on a background of chronic liver disease with aetiology varying by geography and the primary factor being infection with hepatitis B or hepatitis C virus [41]. Liver resection and liver transplantation provide an opportunity for cure. Ablation of lesions and transarterial chemoembolisation can be used to control disease while awaiting transplantation or as palliative measures in advanced disease. The role of chemotherapy has expanded in recent years and will likely become more prominent in the future.

Staging of HCC is important in determining suitability for transplantation. The original 'Milan criteria' of one lesion smaller than 5 cm or 3 lesions smaller than 3 cm, together with no extrahepatic disease or vascular invasion, have been broadened [42]. Patients with no cirrhosis or good preservation of liver function are considered for resection. The use of magnetic resonance imaging (MRI) with liver-specific contrast agents has become the primary mode of investigation of suspected HCC [43]. The requirement, therefore, of laparoscopic staging of HCC is now limited. In centres without access to MRI, LUS can still be useful in guiding treatment decisions [41]. Figure 14.8 and accompanying video demonstrates the typical ultrasound features of HCC. Lesions can be hypo- or hyperechoic with reference to the background liver and often demonstrate a peripheral hypoechoic ring.

Laparoscopic radiofrequency or microwave ablation is becoming an important technique in the management of HCC [44]. LUS is an absolute requirement during laparoscopic ablation. This is discussed in further detail in Chap. 17.

Cholangiocarcinoma

Cholangiocarcinoma is an uncommon malignancy with a poor prognosis: the majority of patients will only be suitable for palliative measures [45]. Tumours may be intrahepatic (IHC), proximal extrahepatic (hilar, HC) or distal (DC) and may be multifocal. Surgery offers the only potential cure in patients with localised disease but is associated with significant morbidity and mortality. Accurate preoperative staging is essential to avoid unnecessary morbidity and to plan the surgical approach to treatment. While improvements in cross-sectional imaging have made a great impact in the staging of other GI malignancies, the evaluation of cholangiocarcinoma remains a challenge even to the most experienced clinician.

Staging laparoscopy and laparoscopic ultrasound (LUS) are commonly used in the evaluation of all types of cholangiocarcinoma, but no randomised controlled trials have been published examining their use. As in other diseases, the great benefit in of laparoscopy is the ability to detect previously undiagnosed peritoneal disease. Laparoscopic ultrasound can detect intrahepatic metastases and provide further information regarding local involvement. In cholangiocarcinoma, the use of staging laparotomy avoids unnecessary laparotomy in a significant proportion of patients with overall yields ranging between studies from 35 to 96 % [2].

Hilar Cholangiocarcinoma

In hilar cholangiocarcinoma, patient- and local tumour-related factors, as well as the presence of metastatic disease, determine resectability (Table 10.3). A study from the authors' own centre showed a yield from laparoscopy alone of 20/82 (24.3 %), where yield is defined as the number of irresectable patients detected at laparoscopy divided by the total number of patients undergoing laparoscopic assessment. This number increased to 35/82 (41.5 %) with the addition of LUS.

An earlier observational study from the Memorial Sloan-Kettering Cancer Center failed to show any benefit with the addition of LUS [46]. In this study, however, LUS was only used in a subset of patients (23/100, 23 %), and a significant proportion went straight to laparotomy with no laparoscopy (76/176, 43 %). In this latter group, 39/76 (51 %) were

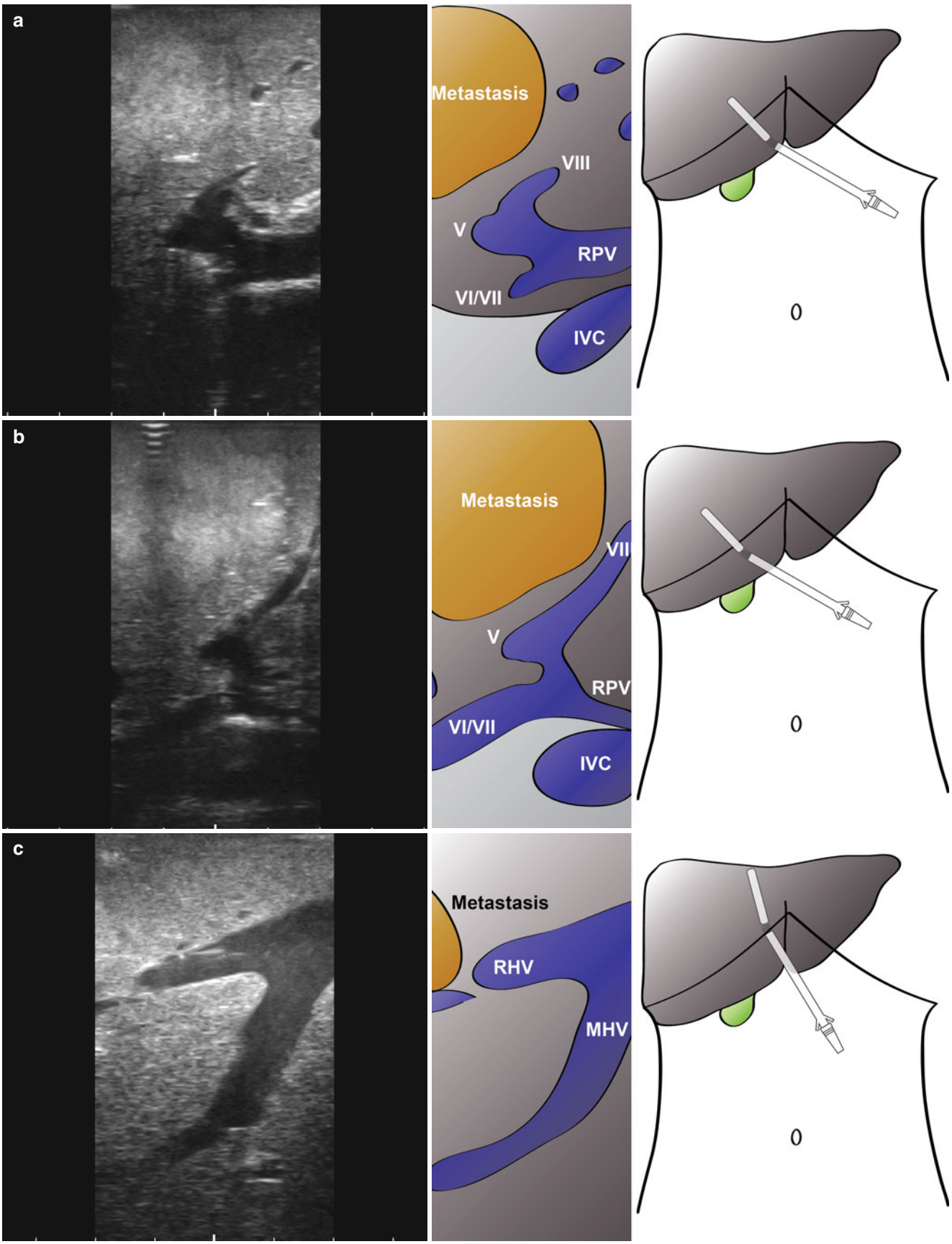

Fig. 10.7 Intraoperative ultrasonography to determine relationship of large colorectal liver metastasis to vascular structures. A local resection was being considered, but ultrasonography clearly shows the tumour abutting the segment VIII pedicle (**a**, **b**, Video 10.1) with no resection margin possible at this structure. In addition, there is indenting and possible invasion of the right hepatic vein (**c**, **d**, Video 10.2; RHV). The patient has a successful open right hepatectomy. MHV, middle hepatic vein; IVC, inferior vena cava; V, segment V pedicle; VI/VII, segement VI/VII pedicle

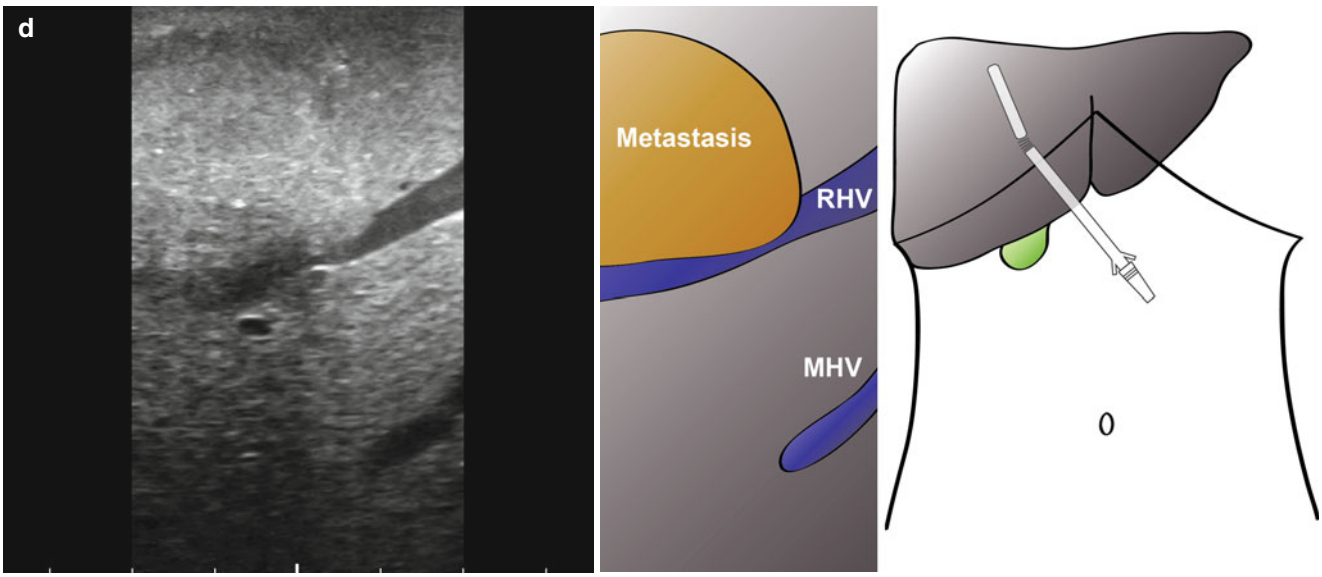

Fig. 10.7 (continued)

Table 10.3 Factors associated with inoperable disease in hilar cholangiocarcinoma

Factors associated with inoperable disease	Evaluable by laparoscopy alone	Evaluable by LUS
Patient factors		
Medically unfit or otherwise unable to tolerate a major operation	–	
Liver cirrhosis	+	++
Local tumour-related factors		
Tumour extension to secondary biliary radicles bilaterally	–	+
Encasement or occlusion of the main portal vein proximal to its bifurcation	–	+
Atrophy of one hepatic lobe with contralateral portal vein branch encasement or occlusion	–	+
Atrophy of one hepatic lobe with contralateral tumour extension to secondary biliary radicles	–	+
Unilateral tumour extension to secondary biliary radicles with contralateral portal vein branch encasement or occlusion	–	+
Metastatic disease		
Histologically proven metastases to N2 lymph nodes	–	+/–
Liver or peritoneal metastases	+	+++

Adapted from Blot et al. [1]

irresectable with 73/176 (41 %) overall having inoperable disease. The authors comment correctly that although LUS might appear useful in the assessment of locally advanced disease, particularly in assessing vascular involvement, its accuracy can be limited by inflammation secondary to biliary stents. Moreover, patients with extensive vascular involvement, which would be readily detected on LUS, are usually identified with cross-sectional imaging prior to surgery.

In our own study, patients judged to be irresectable upon the addition of LUS were, on the whole, found to have locally advanced disease (13/14). Making a decision on resectability on the basis of LUS can be difficult, and surgeons may be uncomfortable doing this. Some may prefer to 'give the patient the benefit of doubt' and perform an exploratory laparotomy to provide further information. Certainly, in most studies, a significant proportion of patients are found to be irresectable at laparotomy despite being deemed resectable on laparoscopy/LUS. In our series, of those that underwent trial dissection, 19/44 (43.2 %) were irresectable: 4 for with peritoneal disease, 10 with locally advanced disease, 3 with metastatic disease and 2 unknown [47].

In a meta-analysis of the role of laparoscopy and LUS in the preoperative staging of pancreaticobiliary cancers [48], 7 studies with 478 patients were examined which focussed on

Table 10.4 Meta-analysis of data from studies analysing staging laparoscopy/LUS in proximal biliary cancers

First author	Year	Laparoscopic examinations	Diagnostic odds ratio[a]	Overall yield (%)
Goere [49]	2006	39	42.8	35.8
Agarwal[b]	–	91	135	43.9
Weber [46]	2002	100	64.8	35
Vollmer [50]	2002	11	35	63.6
Connor [47]	2005	80 (4 failed)	22.2	45
Tilleman [51]	2002	110	105.9	40.9
Kriplani [52]	1992	47	91	95.7
Total (95 % CI)		478	61 (19–189)	47 (42–51)
Heterogeneity, I^2		–	0 %	–

Adapted from Hariharan et al. [48]

[a]Diagnostic odds ratio: the odds of irresectable disease given a positive laparoscopy divided by the odds of irresectable disease given a negative laparoscopy

[b]Error in citation in study, correct citation could not be identified

hilar cholangiocarcinoma. The overall sensitivity and specificity of laparoscopy/LUS in detecting irresectable disease were 63 % (95 % CI 58–68) and 100 % (95 % CI 97–100). Significant variation in sensitivity was seen between studies but could not be explained by further regression analyses. In sensitivity analyses, studies making specific inclusion of LUS were not shown to result in any improvement of diagnostic parameters. A subgroup analysis revealed a high sensitivity for liver and peritoneal lesions but low sensitivity for local/vascular tumour invasion, despite the results of our own study. Again, the overall yield for the use of laparoscopy was 46 % (95 % CI 42–51) (Table 10.4).

Is there a role for targeted laparoscopy/LUS on the basis of the suspected stage of disease? Jarnagin and colleagues have proposed T-stage criteria for hilar cholangiocarcinoma which correlates well with survival [45] and resectability [47]. Palliation in the past has included bypass of the obstructed common bile duct by means of a segment III hepaticojejunostomy. In recent years, this procedure has been superseded by endoscopic metal stent placement, which is superior both in patient tolerability and efficacy. In the past, it may have made sense to have a low threshold for proceeding directly to laparotomy in patients without distant metastases, given that a surgical bypass procedure would be required if the disease was irresectable. However, this is no longer the case, and given the benefits of palliative endoscopic treatment and the necessity to avoid unnecessary laparotomy, all patients with potentially resectable hilar cholangiocarcinoma should undergo staging laparoscopy/LUS prior to open surgical exploration.

Intrahepatic Cholangiocarcinoma

Little has been written about LUS in intrahepatic cholangiocarcinoma. In a small series by Goere, previously undiagnosed peritoneal disease was demonstrated in 4/11 (36 %) [49]. Importantly, of those who went on to attempted resection, 3/7 (42.9 %) were irresectable due to peritoneal disease missed at laparoscopy, vascular involvement or lymph node spread.

In an earlier series from Japan between 1984 and 2001, 62 patients with intrahepatic cholangiocarcinoma underwent laparotomy without a prior staging laparoscopy. Fourteen (23 %) were shown to have peritoneal, liver and lymph node metastases at laparotomy. It has been suggested that an equivalent number of unnecessary laparotomies could have been avoided if staging laparoscopy had been used [53].

On occasion it can be difficult to differentiate malignant and benign lesions of the intrahepatic biliary tree. Figure 10.8 demonstrates a so-called pseudo-tumour, where a suspicious lesion seen on CT is shown on LUS to have a clear acoustic shadow and to be an intrahepatic gallstone (Fig. 10.8, Video 10.3).

Pancreatic and Peri-pancreatic Carcinoma

In this section, pancreatic, ampullary and duodenal cancer, as well as distal cholangiocarcinoma, are considered. Pancreatic cancer is an important cause of cancer-related deaths yet the majority of patients are irresectable at presentation due to liver metastases, peritoneal metastases or locally advanced disease. In the experience of the authors, the median survival of patients who do not undergo a surgical resection is 6 months [55] and is only extended to 24 months in those resected. Given that the outcome for the majority of patients is poor, accurate staging is essential to guide appropriate treatment selection, which unfortunately is most commonly palliation.

The question of whether to perform staging laparoscopy/LUS partly depends on the consequence of identifying irresectable disease. In the recent past, the only effective palliation for the often present biliary obstruction and occasional gastric outlet obstruction has been open surgical bypass. Our

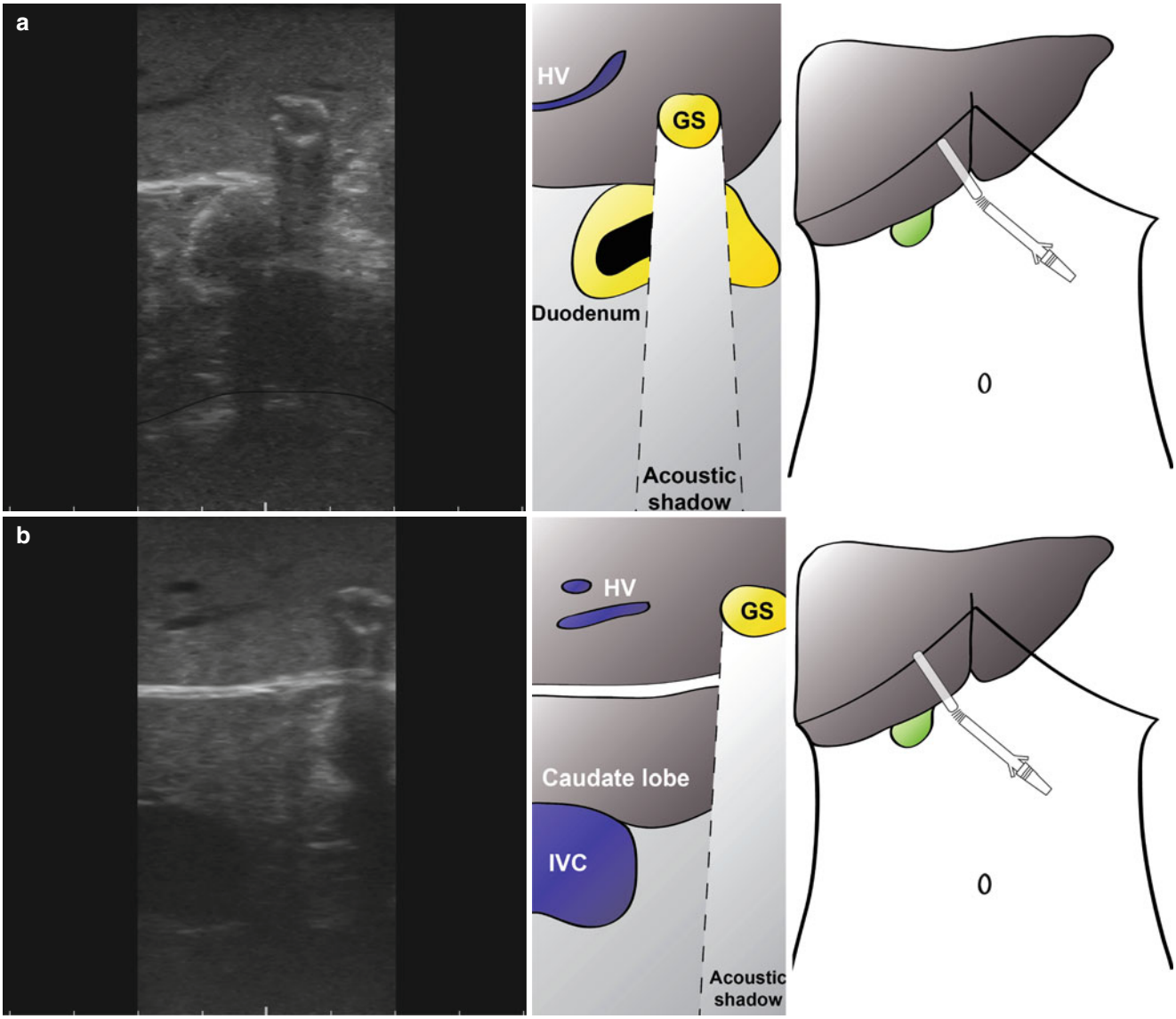

Fig. 10.8 A patient with a suspicious liver lesion which on LUS is demonstrated to be an intrahepatic gallstone (**a**, **b**; see Video 10.3). Benign and malignant lesions can be difficult to differentiate in the biliary tree, as a number of case reports of similar instances describe [54]

own experience reflects a broader appreciation of the benefits of nonoperative palliation: although surgical bypass may be more effective (at the cost of a significant operative procedure), survival is similar following surgical bypass or biliary stenting for jaundice [55]. While the threshold for open exploration used to be low, if preoperative imaging now demonstrates inoperable disease, then endoscopic placement of a self-expanding metal biliary stent and laparoscopic gastrojejunostomy may be considered. The question, therefore, is which group of patients may laparoscopy/LUS benefit?

In an early study from the authors' centre, laparoscopic ultrasonography was used to evaluate 12 patients with suspected adenocarcinoma of the head of the pancreas [56]. Preoperative transabdominal ultrasonography and CT had suggested these patients were all resectable. LUS demonstrated hepatic metastases in four patients, peritoneal disease in two and malignant ascites in one. Overall, LUS demonstrated a contraindication to resection in six patients (50 %). In the six patients subjected to laparotomy, one was found to be resectable due to lymph node metastases.

These observations were followed with a prospective study comparing LUS with USS, CT and selective visceral angiography in determining the TNM stage in 50 patient with pancreatic or peri-ampullary cancers [57]. The gold standard defining resectability in these patients was either biopsy at the time of laparoscopy or subsequent open surgical exploration. The ability to demonstrate irresectability based on T-stage was similar for the four techniques (sensitivity 60–71 %); however, laparoscopic ultrasound was significantly more specific (100 %), i.e. all patients ultimately

resected were thought to be resectable by T-stage on LUS. No modality was accurate in determining N-stage, but laparoscopy was required to identify metastases (sensitivity, USS (29 %), CT (33 %), laparoscopy/LUS (94 %)). LUS though did not significantly improve on laparoscopy alone in this study, as all metastases were superficial and easily visualised. Overall diagnostic accuracy was better with LUS than the other modalities (PPV LUS (97 %) versus CT (79 %)). This study was performed 20 years ago, and since then, the quality of CT imaging has improved dramatically. Does LUS still have a place given this greatly improved non-invasive staging?

Our group revisited the question with a study published in 2006 which aimed to identify a subgroup of patients who may benefit from LUS based on CT assessment of vascular involvement [58]. A CT grade was assigned based on the degree of vascular involvement observed, following which LUS was performed. Of 152 patients who underwent LUS, 56 (37 %) had irresectable disease. In patients with pancreatic and biliary duct dilatation but no mass, three of 26 (12 %) were irresectable, compared with 27 of 88 (31 %) in those with a mass seen not to encircle vessels. However, as expected, the number of irresectable patients was much higher in those with tumour encircling vessels (17 of 29 (59 %)) and all nine patients with tumour occluding vessels. The accompanying Venn diagram (Fig. 10.9) summarises the reasons patients were found to be irresectable at LUS. It was concluded that selective use of LUS in patients with a mass adjacent to but not encircling or obstructing vessels could further differentiate those who are actually resectable. LUS was not deemed useful in those with biliary/pancreatic duct obstruction but no mass or those with clear vessel involvement.

A meta-analysis published in 2010 on the use of staging laparoscopy and LUS in pancreatic-biliary cancers identified

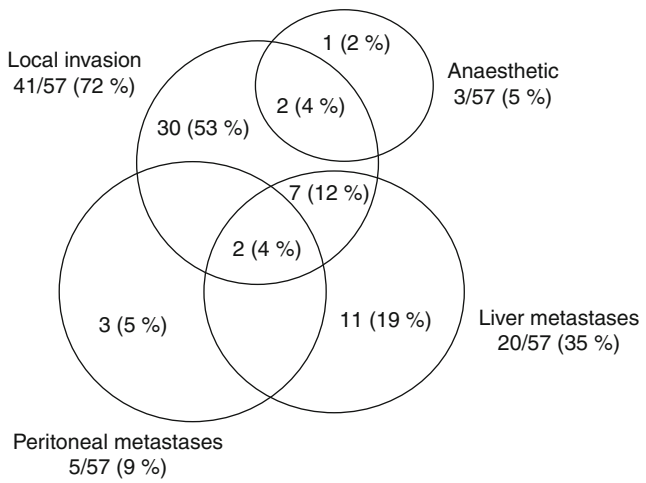

Fig. 10.9 Reason pancreas/ampullary cancer irresectable at laparoscopic ultrasound (From Thomson et al. [58])

22 studies examining pancreatic/peri-pancreatic cancer that satisfied inclusion criteria [48]. The study examined 2,827 patients in studies published over a 13-year period (Table 10.5). The overall sensitivity and specificity of laparoscopy/LUS in this group was 64 % (95 % CI 61–66) and 99 % (95 % CI 99–100) with a true yield of 25 % (95 % CI 24–27) and a diagnostic odds ratio of 104 (48–227). Importantly, the use of laparoscopy/LUS improved the resection rate from 61 to 80 %. In sensitivity analyses, no improvement in diagnostic accuracy was seen in larger studies or studies that fulfilled reporting guidelines. However, studies employing LUS over those using only staging laparoscopy show improved sensitivity and diagnostic odds ratio: 137 (50–376) from 104 (48–227). Similarly, subgroup analysis revealed a high sensitivity for liver and peritoneal lesions but a low sensitivity for local/vascular tumour invasion. The analysis concluded that staging laparoscopy appeared beneficial for the detection of peritoneal disease and surface liver metastases and that laparoscopy should be routine in clinical practice. It made no recommendation on the place of LUS in addition to laparoscopy.

The potential benefits in avoiding an unnecessary laparotomy are reflected in an economic analysis [79]. Using decision modelling, costs and benefits in hypothetical patients with suspected pancreatic cancer were calculated under various scenarios. With best estimates, CT followed by laparoscopy/LUS had an incremental cost-effectiveness ratio of $87,502 per life-year gained, compared with best supportive care, which was significantly more cost-effective than CT/MRI and was less expensive than other imaging strategies. Immediate surgery with no additional imaging for staging was more expensive and less effective than all imaging strategies. The study concluded that a strategy involving CT/laparoscopy/LUS would consistently result in lower costs compared with any other combination of imaging tests under a wide range of scenarios.

Endoscopic ultrasound has become an essential investigation in the assessment of patients with pancreatic cysts or suspected intraductal pancreatic mucinous neoplasm (IPMN), where the underlying diagnosis is in question [80]. Although it is invasive, it does not usually require a general anaesthetic and has the advantage of being to sample tissue from suspicious pancreatic lesions or lymph nodes. Its place in the routine staging of patients with typical features of pancreatic ductal adenocarcinoma on cross-sectional imaging is less clear, although early studies reported EUS to be more sensitive than CT [81] or angiography [82] in the detection of vascular involvement. A recent review concluded that EUS is useful in assessing suspicious lesions that are not well defined on cross-sectional imaging and potentially in the assessment of cases deemed ‘borderline resectable’ due to vascular involvement [83]. This is supported by a recent prospective observational study comparing EUS with CT in

Table 10.5 Individual and overall results following homogenisation of data from studies analysing staging laparoscopy/laparoscopic ultrasound in pancreatic/peri-pancreatic cancers

First author	Year	Laparoscopic examinations	Diagnostic odds ratio[a]	Overall yield (%)
White [59]	2008	1,045	27,308.1	13.8
Enestvedt [60]	2008	86	138.1	27.9
Thompson [58]	2006	152	204.7	36.8
Doucas [61]	2007	98	80.5	56.1
Ahmed [62]	2006	37	103.4	24.3
Karachristos [63]	2005	63	58.9	19
Nieveen Van Dijkum [64]	2003	286	13.6	24.1
Doran [65]	2004	216	40.9	15.2
Zhao [66]	2003	22	153	59
Vollmer [50]	2002	84	46	28.5
Kwon [67]	2002	52	826.3	34.6
Taylor [68]	2001	51	250.6	52.9
Menack [69]	2001	27	111	25.9
Schachter [70]	2000	67	454.1	44.7
Jimenez [71]	2000	125	29.2	31.2
Pietrabissa [72]	1999	42	177	23.8
Durup Scheel-Hincke [73]	1999	34	139.3	55.8
Reddy [74]	1999	98	60.7	29.5
Andrén-Sandberg [75]	1998	24	21.5	37.5
Conlon [76]	1996	108	785.3	37.9
Bemelman [77]	1995	70	22.9	22.8
John [78]	1995	40	50.6	57.5
Total (95 % CI)		2,827	104 (48–227)	25 (24–27)
Heterogeneity χ^2 (p-value), I^2		–	47 ($p=0.001$), 56 %	–

From Hariharan et al. [48]

[a]Diagnostic odds ratio: the odds of irresectable disease given a positive laparoscopy divided by the odds of irresectable disease given a negative laparoscopy

the detection, staging and resectability of pancreatic cancer [84]. In 120 patients enrolled, 104 (87 %) underwent EUS and CT. Of 80 patients with pancreatic cancer, 27 (34 %) were managed nonoperatively, and of the 53 (66 %) who underwent laparotomy, 25 (31 %) had a resection. For these 53 surgical patients, EUS was superior to CT for tumour staging accuracy (67 % vs. 41 %; $P<0.001$) but equivalent for nodal staging accuracy (44 % vs. 47 %; $P>0.2$). In the 25 patients resected, operability was correctly identified by EUS in 88 % and CT in 92 %. Of the 28 patients with irresectable tumours, inoperability was correctly identified by EUS in 68 % and by CT in 64 %. The authors concluded that EUS is superior to CT for T-staging but similar for nodal staging and resectability. It is our own practice to use EUS when there is doubt about the diagnosis or when a patient is clearly irresectable and a tissue diagnosis is required prior to palliative chemotherapy. EUS is not part of our standard preoperative assessment in suspected pancreatic cancer. Please refer to Chap. 11 for more information on EUS.

Distal cholangiocarcinoma and ampullary carcinomas are disease entities in their own right but are usually investigated and staged in the same manner as pancreatic cancer. In an interesting study from 2002, Vollmer examines these different diagnostic categories with the aim of determining the utility of preoperative staging for each [50]. Is laparoscopy +/– LUS equally useful in staging biliary malignancies arising from different sites? Staging laparoscopy was performed in 157 patients. Patients were identified to be irresectable by the following categories: head of pancreas (24/72, 33 %), distal pancreas (2/12, 17 %), gallbladder (7/11, 64 %), distal cholangiocarcinoma (4/23, 18 %) and ampullary/duodenal (0/22, 0 %). LUS was most useful in head of pancreas cancer, where eight patients were demonstrated to be irresectable with the addition of LUS. If the proportions in this study are representative, laparoscopy/LUS seems very useful in head of pancreas and gallbladder cancer, of limited use in distal cholangiocarcinoma and distal pancreas cancer and of no use in ampullary/duodenal cancer.

LUS has also been reported in the investigation of other pancreatic neoplasms and in particular neuroendocrine tumours [18]. A number of studies exist demonstrating the ability of intraoperative in the detection of insulinomas with an accuracy of 83–100 % [85–88].

In conclusion, the benefit of LUS in addition to standard laparoscopy is sensitive to many factors. In studies specifically reporting the added benefit of LUS, irresectable disease is

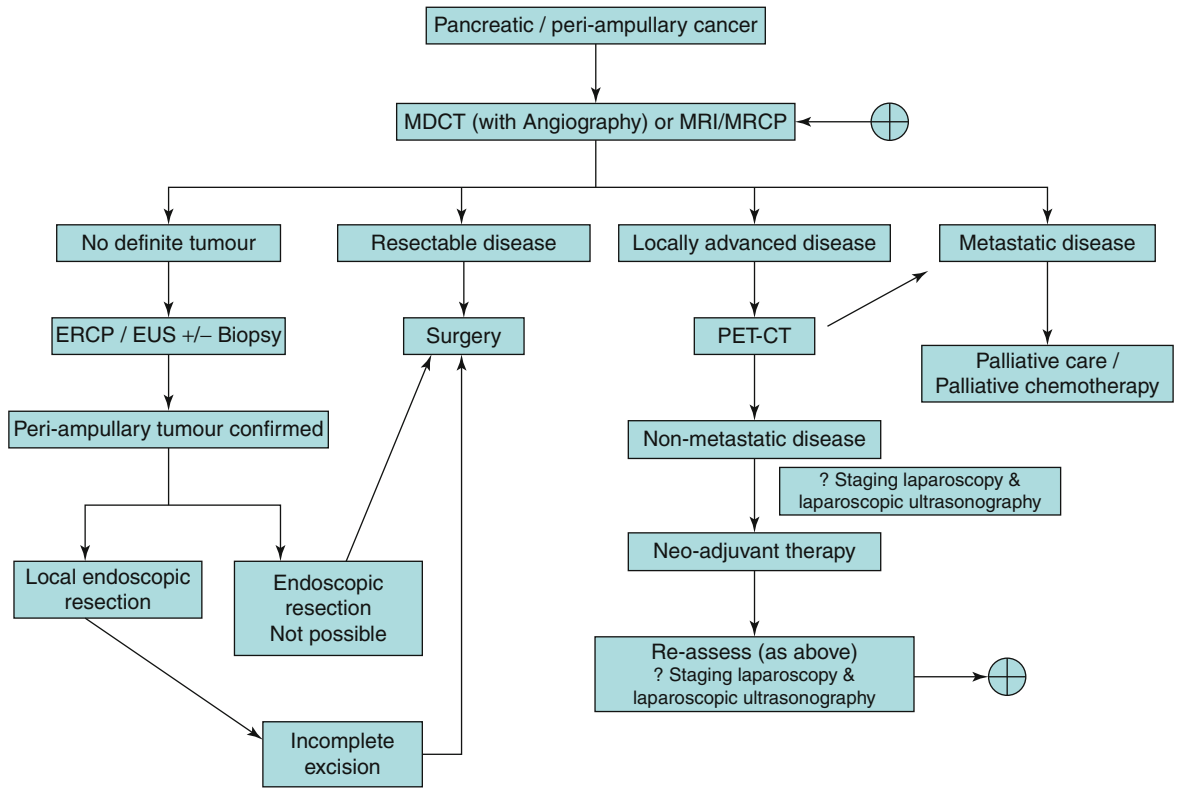

Fig. 10.10 A proposed algorithm outlining the role of the individual imaging modalities in the management of pancreatic and peri-ampullary cancers. *MDCT* multi-detector computed tomography, *MRI* magnetic resonance imaging, *MRCP* magnetic resonance cholangiopancreatography, *PET-CT* positron emission tomography-computed tomography, *EUS* endoscopic ultrasonography, *ERCP* endoscopic retrograde cholangiopancreatography (From Shrikhande et al. [83])

detected in 11–28 % of patients who would have been deemed resectable on laparoscopy alone, with a false-negative rate of 1–8 % [18]. Overall, unnecessary laparotomy can be avoided in 34 % of patients. Patients presenting with gastric outlet obstruction and a CT/MRI demonstrating a potentially resectable tumour should proceed directly to laparotomy, as a hepaticojejunostomy and gastroenterostomy can be performed readily if the tumour is irresectable. In the situation where CT/MRI shows irresectable disease, endoscopic biliary metal stenting should be performed and consideration given to laparoscopic gastroenterostomy in the presence of gastric outflow symptoms. In patients with a CT/MRI that suggests malignancy, but the diagnosis is uncertain, EUS should be considered (Fig. 10.10).

Gallbladder Carcinoma

As suggested in the previous section, laparoscopy/LUS may be useful in the staging of gallbladder carcinoma. A number of older studies have suggested laparoscopy is associated with a yield of 38–62 % [46, 49, 89–92]. There have been few studies that have looked specifically at the added benefit of LUS. The study by Vollmer mentioned above examined 11 patients gallbladder carcinoma [50]. Of those, laparoscopy alone identified 6 (55 %) of patients with metastatic disease. The other six patients all underwent LUS, and a further one of those patients was found to be irresectable.

In a study by Weber and colleagues, 44 patients with potentially resectable gallbladder carcinoma underwent staging laparoscopy +/– LUS. The overall yield was 21/44 (48 %), but a further 15/23 patients were found to be irresectable at laparotomy, giving an accuracy for laparoscopy/LUS of 21/36 (58 %). In this study, LUS did not identify any patients deemed irresectable based strictly on LUS findings alone. Despite the operating surgeons being very experienced, nine patients found to be irresectable at laparotomy had locally advanced disease and a further two had liver metastases.

The largest series of staging laparoscopy in gallbladder cancer was published recently by Agarwal and colleagues, although LUS was not used at all [93]. Of 409 patients with gallbladder cancer who underwent laparoscopy, 95/409 (23 %) had disseminated disease: surface liver metastasis ($n=29$) and peritoneal deposits ($n=66$). The overall yield laparoscopy was 23 % (95/409). Of the 314 patients who underwent laparotomy, an additional 75 had unresectable disease due to missed surface liver metastasis ($n=5$), deep

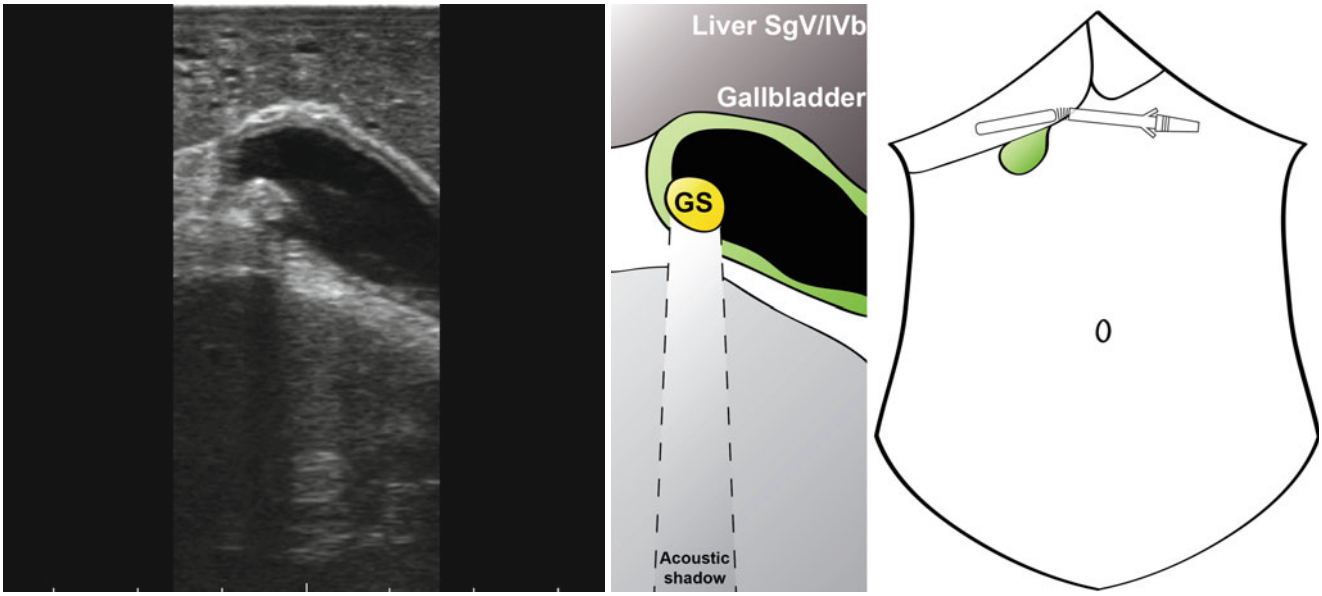

Fig. 10.11 Laparoscopic ultrasound the in the assessment of the gallbladder. In this patient, a suspicious polyp was reported on preoperative imaging. On LUS, only a simple gallstone (*GS*) is seen in the gallbladder, with no wall thickening or infiltrating lesion

parenchymal liver metastasis ($n=4$), peritoneal deposits ($n=1$), non-locoregional lymph nodes ($n=47$) and locally advanced disease ($n=18$). Therefore, the accuracy of laparoscopy for detecting unresectable disease was 55.9 % (95/170). A subgroup analysis of early ($n=56$) versus locally advanced ($n=353$) gallbladder cancer showed an expected greater yield in the latter with accuracy being similar between groups. In this series, would the inclusion of LUS have increased the yield? Four patients had deep parenchymal liver metastases, which would likely have been detected with LUS. A further five patients with surface liver metastases were missed in the early part of the series. If the addition of LUS would have identified these lesions, then the yield would increase from 23.2 to 24.7 % and the accuracy for irresectable disease from 55.9 to 59.4 %.

LUS can be used in patients with indeterminate preoperative imaging. A relatively common situation is the finding of a gallbladder polyp with or without wall thickening in the presence of gallstones. CT can demonstrate the presence of liver infiltration; however, characterisation of the lesion itself can often be difficult. In Fig. 10.11, LUS is used to assess the gallbladder prior to a decision about the appropriateness of a laparoscopic cholecystectomy. In this case, the suspicious lesion had typical appearances of a gallstone on LUS, and a standard laparoscopic cholecystectomy was performed without incident.

A final situation to consider which is unique to the gallbladder is the identification of early-stage carcinoma found incidentally following cholecystectomy for gallstones [94]. Factors determining the outcome of this group include the histological grade of the tumour, involvement of the cystic lymph node if included in the specimen, and whether there was spillage of gallbladder contents during primary cholecystectomy. Curative resection even in patients with advanced disease is possible, although results for patients with T4 disease are poor. Patients should be formally staged with cross-sectional imaging after the histological diagnosis has been made. Little evidence exists, but it is the authors' experience that laparoscopy in this situation is also useful, particularly if there has been bile spillage, given the propensity for peritoneal metastases.

In conclusion, evidence exists of a benefit associated with the use of laparoscopy in the staging of gallbladder cancer. Little has been written specifically about the added benefit of LUS. However, it seems reasonable to suppose that surgeons with experience of LUS are likely to increase the yield and accuracy of in diagnosing irresectable disease given the rate of missed liver metastases on laparoscopy alone.

Complications Associated with Laparoscopy/ LUS

Laparoscopy is a relatively safe procedure, but of course, risks exist related to the anaesthetic, bleeding, damage to structures (including trocar injuries), infection and port-site herniae. In a meta-analysis on the use of laparoscopy in pancreaticobiliary cancers, 9 of 29 studies included information on complications [48]. These included haemorrhage requiring laparotomy ($n=3$), port-site abscess/infection ($n=3$), postoperative pneumonia ($n=2$), post-procedure pancreatitis ($n=2$), bile leak ($n=2$), port-site haematoma ($n=2$) and port-site recurrence ($n=1$). In addition, there was one reported death following laparoscopy due to myocardial infarction.

Conclusion

Laparoscopy with LUS still has a clear benefit over cross-sectional imaging in its ability to diagnose peritoneal disease and to directly biopsy abnormalities. The great improvement of equipment in recent years has delivered to the surgeon a high-resolution flexible tool which can be used to guide treatment decisions. There is a learning curve associated with the technique, but developing LUS skills is essential for those performing many advanced laparoscopic procedures such as liver ablation or resection.

The utility of LUS for staging differs by diagnosis. Laparoscopy is still common in oesophagogastric surgery, and although LUS may downstage gastric cancer, its use is not recommended in guidelines. In colorectal liver metastases and hepatocellular carcinoma studies quote useful LUS yields, but its use in staging alone is now less common given the improved sensitivity of cross-sectional imaging for these conditions. It is a particularly useful though in aiding laparoscopic interventions such as ablation. In pancreaticobiliary cancers including pancreas carcinoma and cholangiocarcinoma, LUS has a useful place in identifying irresectable patients who can be palliated by endoscopic or percutaneous means, thus avoiding a laparotomy. It is in these conditions that LUS still plays a significant role in staging in many centres worldwide.

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