Radiology of the duodenum

E Rachel A Darrah, Daniel J Nolan

Radiological imaging techniques play an important role in the diagnosis of duodenal disorders. The radiological appearances of a variety of interesting but uncommon disorders that involve the duodenum, particularly the duodenal loop, are reviewed.

The current widespread availability and use of upper gastrointestinal endoscopy has resulted in a diminished role for barium radiology in the assessment of the duodenum. At endoscopy lesions are directly visualized and biopsies can be obtained when required. During upper gastrointestinal endoscopy the first part of the duodenum, including the duodenal bulb or cap, where the majority of peptic ulcers occur, is normally the only part of the duodenum that is examined.

A variety of important disorders may be encountered in the second, third and fourth parts of the duodenum and it is in the detection and evaluation of these lesions that barium radiology, somtimes supplemented by computed tomography (CT), ultrasound or magnetic resonance imaging (MRI), has an important role to play. Barium radiology is also the method of choice for showing the full extent and morphological appearances of lesions that cause stricturing of the duodenum.

The duodenum is well shown during routine double-contrast barium examination of the upper gastrointestinal tract. Hypotonic duodenography is performed, sometimes with the use of a duodenal tube to introduce the barium and air, for evaluating a known or suspected abnormality of the duodenal loop. Enteroclysis (small bowel enema) is now widely used for examining the jejunum and ileum and occasionally a duodenal abnormality is found during the examination to account for the patient's symptoms.

In this article the radiological appearances of the abnormalities that are likely to be encountered in the duodenum (*Table 1*) are reviewed.

Dr E Rachel A Darrah is Specialist Registrar in Radiology and **Dr Daniel J Nolan** is Consultant Radiologist, John Radcliffe Hospital, Oxford OX3 9DU

Correspondence to: Dr DJ Nolan

PEPTIC ULCERATION

Benign peptic ulceration of the duodenal cap is a commonly encountered condition. However, with modern drug therapy the ulcers have frequently healed before the patient is investigated by barium examination or endoscopy.

Typically, ulcer craters in the duodenum are of varying size and can be single or multiple. They are shown on double-contrast barium studies as well defined collections of barium, often with a surrounding zone of oedema and radiating folds (*Figure 1*). Most craters are less than 10 mm in diameter. The duodenal cap may be deformed and the degree of the deformity varies considerably and can result in duodenal stenosis. Sizeable ulcer craters can occur in the absence of any duodenal deformity. Duodenal deformity may be permanent following previous peptic ulceration.

Giant duodenal ulcers

Giant duodenal ulcers are benign peptic ulcers with a radiographic diameter of greater than

Figure 1. Duodenal ulcer. A moderate-sized ulcer crater (arrowhead) is seen in the duodenal cap with surrounding oedema and a number of radiating folds. The duodenal cap is not significantly deformed.

2 cm (Lumsden et al, 1970). The ulcer, because of its large size, may be mistaken for the duodenal bulb or a large diverticulum. Patients are usually of an advanced age and the ulcers frequently fail to heal on medical treatment. Complications such as haemorrhage, obstruction or penetration of an adjacent organ occur. The ulcers are round or oval with a sharp well-defined outline (*Figure 2*). When the ulcer is penetrating an adjacent organ, irregularity of the floor of the ulcer may be seen.

Figure 2. Giant duodenal ulcer. A giant ulcer crater is seen in the duodenal cap (arrowheads). This collection of barium resembles the duodenal cap itself but was unchanged in size or shape on a number of views when visualized on fluoroscopy. The patient, an 83-year-old man, was admitted with acute upper gastrointestinal bleeding. Endoscopy was performed and a large ulcer crater was seen, which was considered to be malignant. This examination was requested to confirm the diagnosis. As the radiological appearances were characteristic of a giant benign peptic ulcer, medical treatment was prescribed and the patient made a full recovery with no subsequent recurrence of symptoms.

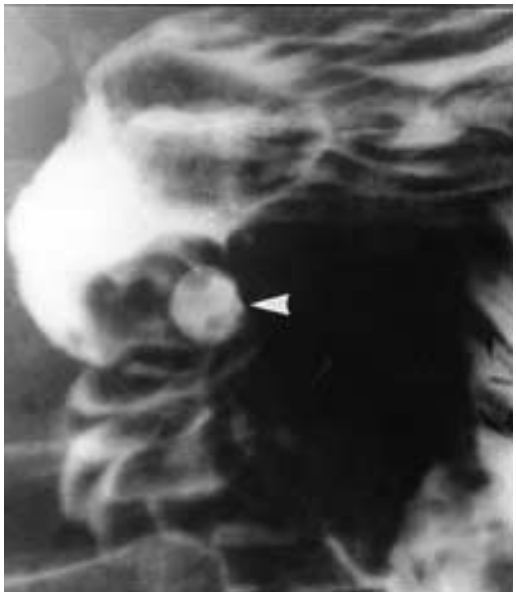

Figure 3. Post-bulbar ulcer. A moderate sized ulcer crater is shown on the medial aspect of the proximal second part of the duodenum (arrowhead) with surrounding oedema.

Post bulbar ulceration

Post bulbar ulceration is less common but when present is located in the concave border of the second part or in the immediate post bulbar area (Nolan, 1997). The ulcer is shown as a typical crater (*Figure 3*) and there may be adjacent narrowing of the lumen and thickening of mucosal folds. Post bulbar ulcers often fail to heal on medical treatment and complications such as haemorrhage, stenosis, perforation and penetration into an adjacent organ are a frequent occurrence (Moser and Schmitt, 1962).

TABLE 1.
Duodenal disorders

Peptic ulceration	Duodenal cap ulceration			
	Giant duodenal ulcers			
	Post bulbar ulceration			
	Zollinger–Ellison syndrome			
Crohn's disease				
Diverticula				
Neoplasms	Benign	Brunner's gland hyperplasia		
		Lymphoid hyperplasia		
		Adenomas		
		Leiomyomas		
		Lipomas		
	Malignant	Primary	Adenocarcinoma	
			Leiomyosarcoma	
			Lymphoma	
			Kaposi's sarcoma	
		Secondary	Direct spread	Stomach
				Pancreas
				Colon
				Right kidney
				Gallbladder
			Lymphatic spread	Left kidney
			Haemotogenous spread	Melanoma
				Breast
				Lung
				Testis
				Kidney
				Liposarcoma
Miscellaneous disorders	Intramural haematoma			
	Bouveret's syndrome			
	Duodenal varices			

Zollinger–Ellison syndrome

Duodenal ulceration is a feature of the Zollinger–Ellison syndrome and when located in the duodenal cap cannot be differentiated from ordinary peptic ulceration. However, gastric and duodenal ulcers may occur simultaneously and the duodenal ulcers are often multiple (Nelson and Lichtenstein, 1983). Ulcers in the Zollinger–Ellison syndrome tend to occur in unusual sites, particularly the distal duodenum and proximal jejunum, and there is usually associated thickening of the duodenal folds.

CROHN'S DISEASE

Radiological evidence of Crohn's disease is seen in the duodenum in about 4% of patients with involvement of the jejunum, ileum or colon (Fielding et al, 1970), although aphthoid ulcers are seen in the duodenum in 22% of patients with established Crohn's disease (Ariyama et al, 1980). The appearances of duodenal Crohn's disease are similar to those seen in the more distal small intestine. Thickening, distortion and fusion of the valvulae conniventes may be seen.

When the disease process is more advanced there may be strictures with eccentric or concentric narrowing (Fielding et al, 1970). Other characteristic signs that may be seen include cobblestoning, asymmetry and skip lesions. Fissure ulcers, sinuses and fistulae are uncommon. A characteristic finding of gastroduodenal Crohn's disease is seen when there is tubular narrowing of the antrum and proximal duodenum in continuity producing the 'pseudo post-Billroth I' or 'Ram's Horn' appearance (*Figure 4*) (Nelson, 1969).

DIVERTICULA

Diverticula are a fairly common finding in the duodenum on barium studies (2–5%), with about 85% arising from the medial surface (*Figure 5*) (Levene and Scheff, 1962). The great majority of duodenal diverticula are asymptomatic, although occasionally they contain aberrant pancreatic, gastric or other functioning tissue that can cause ulceration, perforation or gangrene (Levene and Scheff, 1962). Cholangitis or pancreatitis may develop when the papilla of Vater is located in a duodenal diverticulum (Rose, 1975) and difficulty may arise with duct cannulation during endoscopic retrograde cholangiopancreatography (ERCP).

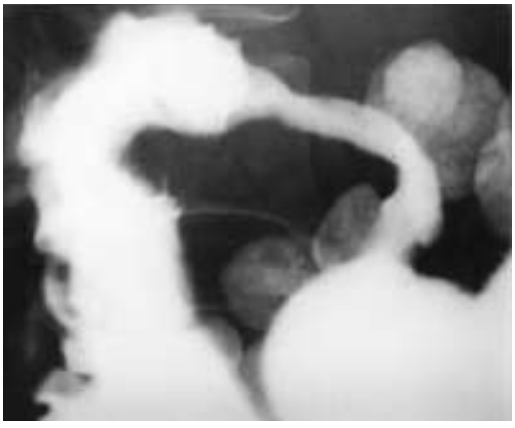

Figure 4. Crohn's disease. There is narrowing of the distal gastric antrum in continuity with the pyloric canal and duodenal bulb.

NEOPLASMS

Benign neoplasms

Benign neoplasms are an uncommon finding in the duodenum and are often symptomless. Brunner's gland hyperplasia is the most frequently encountered benign neoplastic disorder. Benign lymphoid hyperplasia is occasionally seen in the duodenum. Other benign neoplasms that are occasionally encountered in the duodenum include leiomyomas, adenomas, lipomas, neurogenic tumours and hamartomas.

Brunner's gland hyperplasia: Brunner's glands are mostly found in the submucosa of the duodenal bulb, rapidly decreasing in number distal to the papilla of Vater and are not found distal to the ligament of Treitz (Robertson, 1941). The duodenal cap is the most frequent site of Brunner's gland hyperplasia. Brunner's gland hyperplasia represents a response to prolonged stimulation by gastric hyperacidity and most cases are associated with peptic duodenitis (Merine et al, 1991). On barium studies Brunner's gland hyperplasia may be seen as a solitary submucosal nodule or as multiple, fairly large filling defects in the duodenal bulb (*Figure 6*).

Lymphoid hyperplasia: Lymphoid hyperplasia is occasionally seen in the duodenum (Govoni, 1976). The nodules are particularly well shown

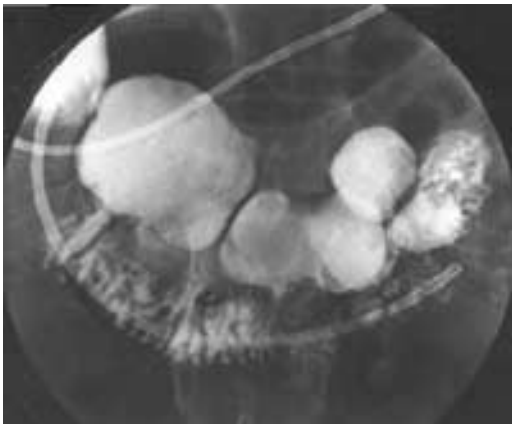

Figure 5. Diverticula. A number of small and large diverticula are shown communicating with the medial aspect of the duodenal loop.

on double-contrast barium views of the duodenal cap where they are seen as multiple small (1–2 mm) filling defects (*Figure 7*).

Adenomas: Adenomas are rarely seen in the duodenum. They are shown as single round filling defects similar to adenomas in other parts of the gastrointestinal tract and, like them, are at risk of malignant transformation. Multiple adenomatous polyps may be seen in the duodenum in familial polyposis coli (Yonemoto et al, 1969). A characteristic frond-like appearance may be seen in villous adenoma (Ring et al, 1972).

Leiomyomas: Leiomyomas are the most frequently encountered benign neoplasm of the jejunum and ileum but are rarely seen in the duodenum. They are seen as small intraluminal or intramural filling defects, sometimes with a central ulcer crater. The extraluminal component is best shown by CT.

Lipomas: Duodenal lipomas are rare. They may be seen as a smooth round or oval intramural mass resembling other benign neoplasms, or they may present with characteristic appearances such as a large elliptical mass that conforms to the lumen of the duodenum (*Figure 8a*) and changes shape with peristalsis or compression (Cho, 1997). The low fat attenuation of the mass on CT is diagnostic (*Figure 8b*).

Other benign neoplasms: Neurogenic tumours and hamartomas are extremely rare and are normally indistinguishable radiologically from adenomas and leiomyomas.

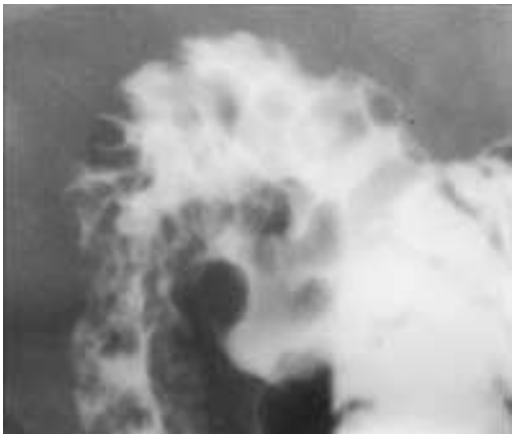

Figure 6. Brunner's gland hyperplasia. Multiple moderate sized confluent submucosal filling defects are seen in the duodenal cap.

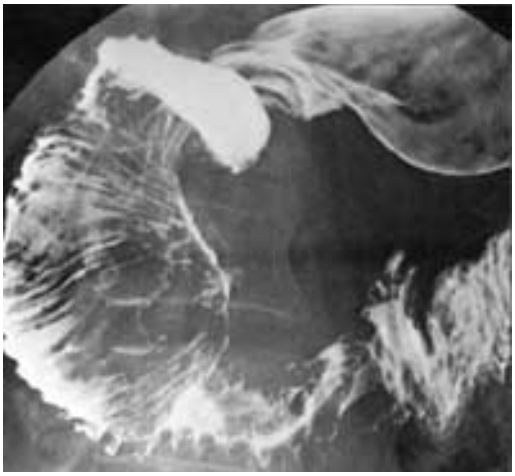

Figure 7. Lymphoid hyperplasia. Multiple small filling defects characteristic of lymphoid hyperplasia are shown on a double-contrast view of the duodenal cap.

Malignant neoplasms

Malignant neoplasms are uncommon in the duodenum. Primary adenocarcinoma accounts for about 80–90% of all primary malignant duodenal neoplasms (Bosse and Neely, 1969; Cortese and Cornell, 1972); leiomyosarcoma and lymphoma account for less than 15% (Meyers 1971; Kanematsu et al, 1991). Other neoplasms that are occasionally encountered in the duodenum include Kaposi's sarcoma, carcinoid tumour, malignant schwannoma, lymphangiosarcoma

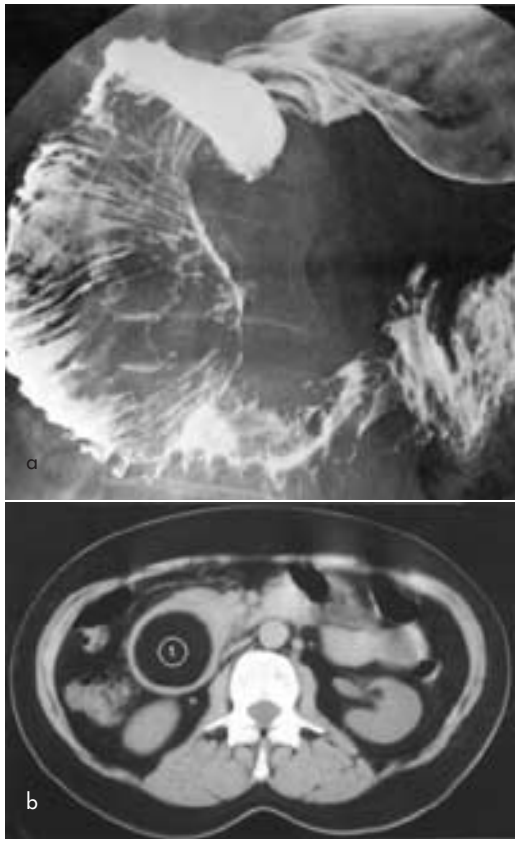

Figure 8. Lipoma. a. A large intraluminal filling defect is seen occupying and expanding the second part of the duodenum in a patient who presented with vomiting. b. Computed tomography shows that the lesion is a round homogeneous intraluminal mass with low attenuation values equivalent to those of fat.

and plasmacytoma (Cho, 1997). Secondary neoplastic involvement of the duodenum occurs by direct spread from adjacent organs, as blood-borne metastases or lymphatic spread.

Primary neoplasms: ***Carcinoma:*** The duodenum is the most common site of primary carcinoma in the small intestine; most of the rest are located in the jejunum, particularly in the proximal jejunum. They are adenocarcinomas and are mostly located in the second, third and fourth part of the duodenum. The aetiology of duodenal carcinoma is unknown. Most patients with carcinoma present with obstructive symptoms such as abdominal pain, nausea, vomiting, weight loss and occasionally haemorrhage (Cortese and Cornell, 1972). Carcinoma of the duodenum has a poor prognosis with a mean survival time of about 21 months (Nix et al, 1985).

The radiological appearances of carcinoma of the duodenum are similar to those of carcinoma elsewhere in the gastrointestinal tract (Bosse and Neely, 1969). Characteristically, the lesion is shown on barium examination as a stricture with mucosal destruction and shouldered margins (*Figure 9*). An irregular polypoid mass or an ulcerating lesion with adjacent mucosal destruction (*Figure 10*) are also seen in some cases. On CT, duodenal carcinoma is seen mostly as asymmetrical thickening of the duodenal wall or as a polypoid mass.

Leiomyosarcoma: Leiomyosarcoma accounts for less than 10% of primary malignant neoplasms of the duodenum (Wilson et al, 1974). Clinical presenting symptoms of leiomyosarcoma include acute gastrointestinal bleeding, anaemia, abdominal pain, weight loss or a palpable abdominal mass (Cho, 1997). Most leiomyosarcomas grow extraluminally and are shown on barium examination as intramural filling defects with central ulceration, cavitation or sinus tracks (Meyers, 1971). On CT leiomyosarcomas are seen as a large irregular, low attenuation duodenal mass with central necrosis (Kanematsu et al, 1991). The tumour mass is usually greater than 5 cm in diameter and is mostly extraluminal in location. Metastatic spread may be present at the time of diagnosis and the mean survival time following diagnosis and resection is 10–38 months.

Lymphoma: Most duodenal lymphomas are of the non-Hodgkin's variety and result from spread of gastric lymphoma across the pylorus or as encasement by involved paraduodenal lymph nodes. Duodenal involvement is frequently seen in Mediterranean lymphoma complicating immunosuppressive small intestinal (α-chain) disease (Khojasteh et al, 1983). Primary duodenal lymphoma is rare because of the paucity of lymphoid tissue in the duodenum (Balikian et al, 1969). Most of the cases reported in the literature show symmetrical thickening of the duodenal wall on radiological examination. Other appearances that may be seen resemble those of primary ileal lymphoma and include a polypoid mass or multiple nodules. A large cavitating mass may be seen, indistinguishable from leiomyosarcoma or a metastasis.

Figure 9. Carcinoma. An irregular stricture with mucosal destruction and shouldered margins is shown in the third part of the duodenum (arrow).

Figure 10. Carcinoma. There is a tight stricture with mucosal destruction and a large central ulcer (arrow) in the proximal second part of the duodenum. This proved to be a primary duodenal carcinoma.

Kaposi's sarcoma: Kaposi's sarcoma may be seen in patients with acquired immune deficiency syndrome (AIDS) and is frequently seen as multiple submucosal nodules, sometimes with central ulceration.

Secondary neoplasms: ***Direct spread:*** Gastric carcinoma and lymphoma can spread across the pylorus to invade the duodenum. A recent study by Cho and colleagues (1996) showed that transpyloric spread occurred in 40% of lymphomas and 25% of adenocarcinomas of the gastric antrum. These were seen on barium examination as contour deformities and nodular filling defects in the duodenal bulb.

Carcinoma of the pancreas frequently causes changes in the duodenal loop. On barium studies widening of the duodenal loop, a double contour, irregularity of the inner margin or stricture formation are seen. Occasionally the characteristic reversed '3' sign of Frostberg (*Figure 11*) is seen (Frostberg, 1938). Carcinoma of the body and tail of the pancreas may invade the fourth part of the duodenum and cause mucosal destruction, ulceration or a stricture with obstruction (*Figure 12*) (Mani et al, 1966). CT will demonstrate the primary neoplasm as well as the extent of duodenal invasion (Cho, 1997).

Carcinoma of the colon, particularly the hepatic flexure may spread to invade the duodenum; occasionally the patient presents with duodenal symptoms before the primary carcinoma has been detected (Treitel et al, 1970; Diamond et al, 1981). On barium examination a constricting lesion (*Figure 13*) or a post bulbar ulcer with adjacent mucosal destruction is seen. Occasionally duodenal invasion results in a duodenocolic fistula. CT shows extensive tumour invasion (Diamond et al, 1981). Other carcinomas that may invade the second part of the duodenum by direct spread include carcinomas of the right kidney, gallbladder and common bile duct.

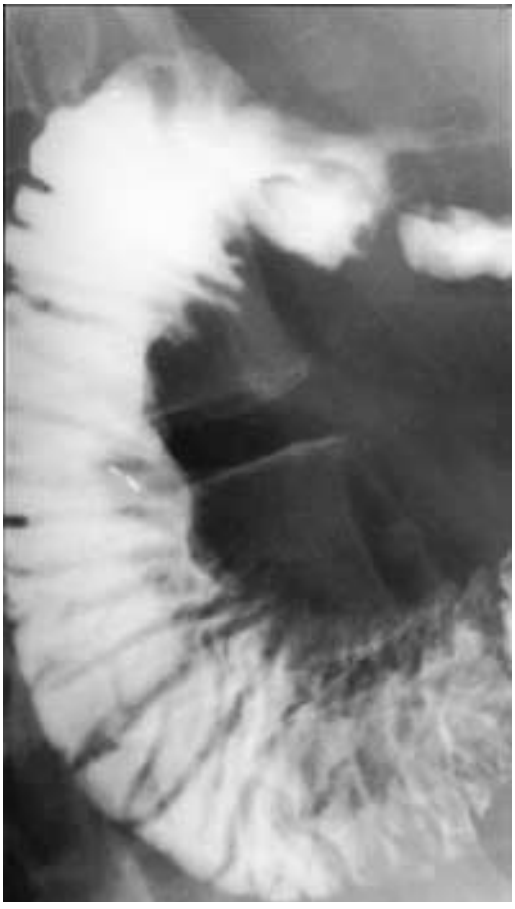

Figure 11. Carcinoma of the pancreas. A barium examination shows effacement of the normal mucosal pattern on the medial aspect of the second part of the duodenum with the typical reversed '3' appearance.

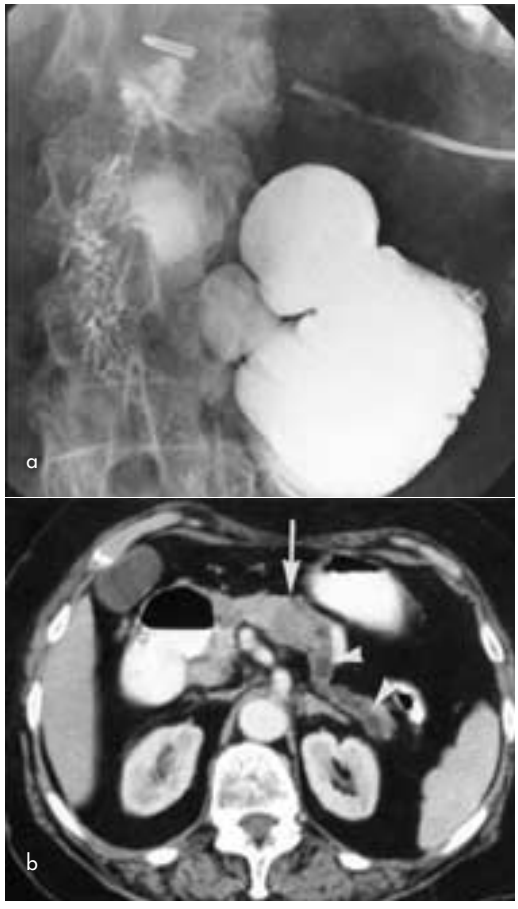

Figure 12. Carcinoma of the pancreas. a. Barium examination shows complete obstruction with some dilatation of the duodenum just proximal to the duodenojejunal flexure (ligament of Treitz). A number of duodenal diverticula are also seen. b. Computed tomography confirms the presence of a pancreatic carcinoma (arrow) in the body of the pancreas. Note the marked dilatation of the pancreatic duct in the tail of the pancreas (arrowheads).

Lymphatic spread: Lymphatic spread from carcinoma of the left kidney to the fourth part of the duodenum occasionally occurs.

Blood-borne metastases: Malignant melanoma is the most common neoplasm to metastasize to the duodenum. Other primaries that metastasize to the duodenum include carcinoma of the breast, lung, testis, kidney, liposarcoma (*Figure 14*) and rarely osteogenic sarcoma. Metastases may be shown on barium examination as small submucosal nodules, often multiple in metastatic melanoma. Metastatic breast carcinoma may produce a diffuse infiltrative lesion with a scirrhous appearance (Cho, 1997). A metastasis may be seen as a large solitary mass, sometimes with a central cavity indistinguishable from leiomyosarcoma or lymphoma.

MISCELLANEOUS DISORDERS

Intramural haematoma

Intramural haematoma may develop in the duodenum as a result of blunt trauma, or more frequently, in patients with blood dyschrasias and those on anticoagulant therapy (Frostick et al, 1984). Abdominal pain and vomiting is the char-

Figure 13. Carcinoma of the colon invading the duodenum. Barium examination shows a tight stricture with mucosal destruction involving much of the second part of the duodenum with an abrupt transition at both ends of the lesion. At operation this proved to be invasion from an adjacent primary carcinoma in an inverted caecum, which was positioned adjacent to the second part of the duodenum.

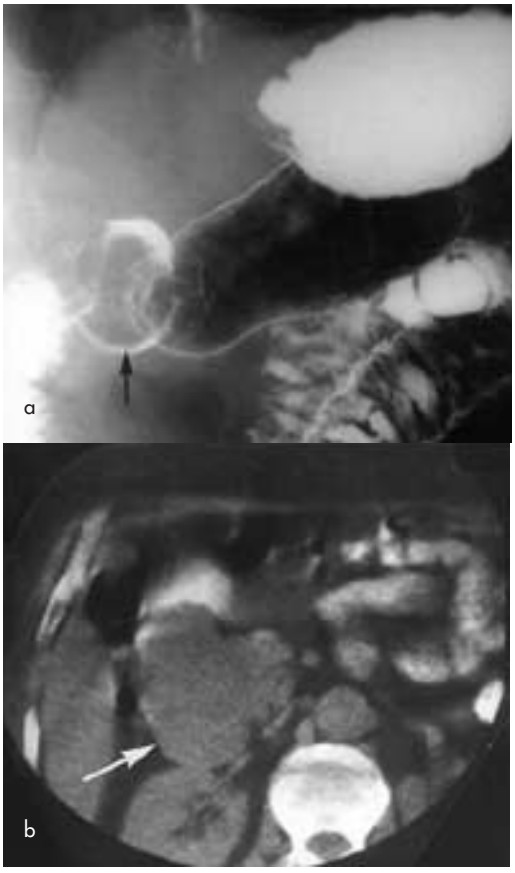

Figure 14. Metastasis to duodenum. a. A barium examination shows a large filling defect occupying the duodenal cap (arrow). b. Computed tomography shows a large irregular mass invading the duodenum. This proved to be a metastatic liposarcoma; the patient had previously had a primary liposarcoma resected from the thigh.

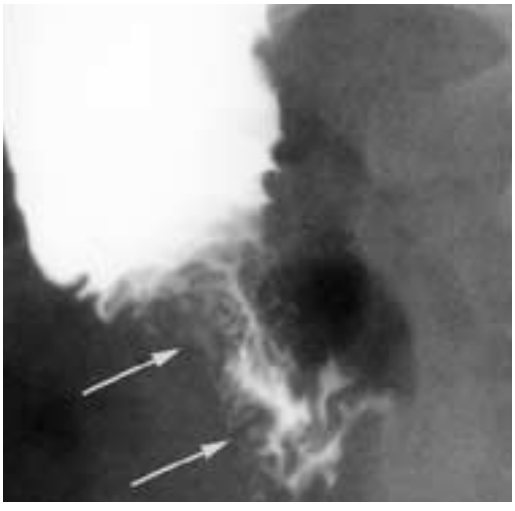

Figure 15. Intramural haematoma following anticoagulant therapy. Marked circumferential narrowing (arrows) is shown in the distal second part of the duodenum. There is preservation, but distortion, of the mucosal folds. The diagnosis of intramural haematoma was confirmed at operation when the patient failed to improve after 7 days conservative treatment.

acteristic clinical presentation. Barium examination often shows the intramural haematoma as a concentric obstructive lesion with retention of the normal mucosal pattern (*Figures 15* and *16*). Sometimes there is distortion with thickening of the valvulae conniventes producing the 'coiled spring' appearance (Felson and Leven, 1954). CT characteristically shows mixed attenuation of the haematoma following intravenous contrast medium (*Figure 16*).

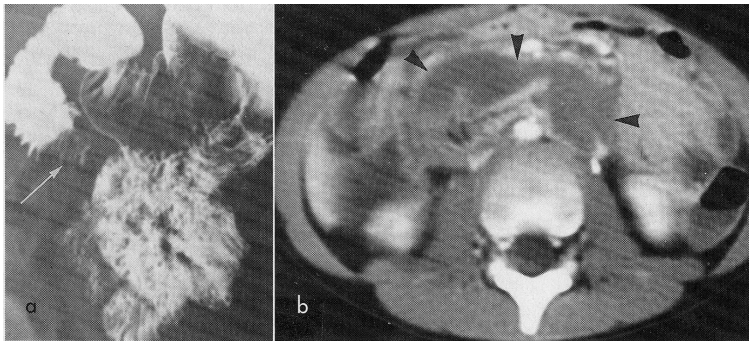

Figure 16. Intramural haematoma. a. Barium examination shows narrowing and deformity of the third part of the duodenum (arrow) in a child following blunt abdominal trauma. b. Computed tomography shows mixed attenuation lesion characteristic of haematoma surrounding the third part of the duodenum (arrowheads).

Bouveret's syndrome

Gastric outlet obstruction due to a gallstone obstructing the duodenum bulb is known as Bouveret's syndrome, as he reported the first two cases in 1896. The condition is rare but awareness of this complication of biliary disease is important as a review of the published cases shows that the mortality rate is high. Figiel and Figiel (1956) were the first to describe the radiological features of Bouveret's syndrome. Barium studies show the calculus as a radiolucent mass filling the entire duodenal bulb with a thin coating of barium between the periphery of the calculus and the wall of the duodenum (*Figure 17*). A fistulous communication to the gallbladder is frequently seen (*Figure 17*).

Figure 17. Bouveret's syndrome. A large gallstone is seen occupying much of the first part of the duodenum. A rim of barium identifies the outline of the calculus and the adjacent wall of the duodenum. Note the fistulous track (arrowhead) extending from the duodenum.

Duodenal varices

Varices are occasionally encountered in the duodenum. They are mostly seen in patients with extra-hepatic portal hypertension (Itzchak and Glickman, 1977), although they may occur in portal hypertension where there is no evidence of extra-hepatic obstruction (Perchick and Max, 1963). It is important to recognize duodenal varices as inadvertent biopsy can cause catastrophic bleeding. Duodenal varices are shown on barium studies as nodular lesions, marginal indentations of wall or as a serpiginous filling defect (*Figure 18*) in the duodenal cap. **HM**

Figure 18. Varix. A serpiginous filling defect (arrowheads) is seen in the duodenal cap in a patient with extrahepatic portal hypertension.

Figures 3, 9, 10 *and* 18 *are reproduced from Nolan (1983).*
Figure 16 *is reproduced courtesy of Dr Kieran McHugh.*

Ariyama J, Wehlin L, Lindstrom CG, Wenkert A, Roberts GM (1980) Gastroduodenal erosions in Crohn's disease. *Gastrointest Radiol* **5:** 121–5

Balikian JP, Nassar NT, Shamma'a MH, Shahid MJ (1969) Primary lymphomas of the small intestine including the duodenum: a Roentgen analysis of twenty-nine cases. *Am J Roentgenol* **107:** 131–41

Bosse G, Neely JA (1969) Roentgenologic findings in primary malignant tumours of the duodenum. *Am J Roentgenol* **107:** 111–8

Cortese AF, Cornell GN (1972) Carcinoma of the duodenum. *Cancer* **29:** 1010–5

Cho KC, Baker SR, Alterman DD, Fusco JM, Cho S (1996) Transpyloric spread of gastric tumours: comparison of adenocarcinoma and lymphoma. *Am J Roentgenol* **167:** 467–9
Cho KC (1997) Neoplasms of the duodenum. In: Gourtsoyiannis NC, Nolan DJ, eds. *Imaging of Small Intestinal Tumours.* Elsevier, Amsterdam: 247–82
Diamond RT, Greenberg HM, Boult IF (1981) Direct metastatic spread of right colonic adenocarcinoma to duodenum - barium and computed tomography findings. *Gastrointest Radiol* **6:** 339–41
Felson B, Leven EJ (1954) Intramural haematoma of the duodenum: diagnostic roentgen sign. *Radiology* **63:** 823–31
Fielding JF, Toye DKM, Beton DC, Cooke WT (1970) Crohn's disease of the stomach and duodenum. *Gut* **11:** 1001–6
Figiel LS, Figiel SJ (1956) Gallstone obturation of the duodenal bulb. *Am J Roentgenol* **76:** 24–31
Frostberg N (1938) Characteristic duodenal deformity in cases of different kinds of peri-vaterial enlargement of the pancreas. *Acta Radiol* **19:** 164–73
Frostick SP, Collin J, Daar AS, Kettlewell M, Nolan DJ (1984) Non-traumatic intramural haematoma: an unusual case of duodenal obstruction. *Br J Surg* **71:** 313–4
Govoni AF (1976) Benign lymphoid hyperplasia of the duodenal bulb. *Gastroiontest Radiol* **1:** 267–9
Itzchak Y, Glickman MG (1977) Duodenal varices in extrahepatic portal obstruction. *Radiology* **124:** 619–24
Kanematsu M, Imaeda T, Iinuma G et al (1991) Leiomyosarcoma of the duodenum. *Gastrointest Radiol* **16:** 109–12
Khojasteh A, Haghshenass M, Haghighi P (1983) Current concepts: immunoproliferative small intestine disease. A 'Third World lesion'. *N Engl J Med* **308:** 1401–5
Levene G, Scheff S (1962) The clinical significance of duodenal diverticula. *Am J Dig Dis* **7:** 877–85
Lumsden K, MacLarnon JC, Dawson J (1970) Giant duodenal ulcer. *Gut* **11:** 592–9
Mani JR, Zboralske FF, Margulis AR (1966) Carcinoma of the body and tail of the pancreas. *Am J Roentgenol* **96:** 429–46
Merine D, Jones B, Ghahremani GG, Hamilton SR, Bayless TM (1991) Hyperplasia of Brunner glands: the spectrum of its radiographic manifestations. *Gastrointest Radiol* **16:** 104–8
Meyers MA (1971) Leiomyosarcoma of the duodenum. *Clin Radiol* **22:** 257–60
Moser F, Schmitt H (1962) Postbulbar duodenal ulcer. *Fortscher Geb Roentgenstr Nuklearmed* **97:** 592–7
Nelson SW (1969) Some interesting and uusual manifestations of Crohn's disease (regional enteritis) of the stomach, duodenum and small intestine. *Am J Roentgenol* **107:** 86–101
Nelson SW, Lichtenstein JE (1983) The Zollinger Ellison syndrome. In: Marshak RH, Lindner AE, Maklansky D, eds. *Radiology of the Stomach.* Saunders, Philadelphia: 334–81
Nix GA, Wilson JH, Dees J (1985) Primary malignant tumours of the duodenum. *Fortschur Geb Roentgenstr Nuklearmed* **142:** 385–90
Nolan DJ (1983) *Radiological Atlas of Gastrointestinal Disease.* John Wiley: Chichester, New York
Nolan DJ (1997) The duodenum. In: Grainger RG, Allison DJ, eds. *Diagnostic Radiology. A Textbook of Medical Imaging.* Churchill Livingstone, Edinburgh: 973–83
Perchick L, Max TC (1963) Massive haemorrhage from varices of the duodenal loop in a cirrhotic patient. *Radiology* **80:** 641–4
Ring EJ, Ferrucci JT, Eaton SB, Clements JL (1972) Villous adenomas of the duodenum. *Radiology* **104:** 45–8
Robertson HE (1941) The pathology of Brunner's glands. *Arach Pathol* **31:** 112–30
Rose PG (1975) Clinical and radiological features of aberrant insertion of the common bile duct. *Clin Radiol* **26:** 121–7
Treitel H, Meyers MA, Maza V (1970) Changes in the duodenal loop secondary to carcinoma of the hepatic flexure of the colon. *Br J Radiol* **43:** 209–13
Wilson JM, Melvin DB, Gray GF, Thorbjarnarson B (1974) Primary malignancies of the small bowel: a report of 96 cases and review of the literature. *Ann Surg* **180:** 175–9
Yonemoto RH, Slayback JB, Byron RL, Rosen RB (1969) Familial polyposis of the entire gastrointestinal tract. *Arch Surg* **99:** 427–34

KEY POINTS

- Most of the duodenum is beyond the reach of routine upper gastrointestinal endoscopy.
- A number of uncommon but important disorders involve the second, third and fourth parts of the duodenum.
- Barium radiology remains an ideal technique for detecting duodenal abnormalities.
- The extent of duodenal lesions and their effect on the calibre of the duodenum are well shown by barium examination.
- Further information, particularly the extraluminal extent of lesions involving the duodenum, can be obtained by other inaging techniques, particularly computed tomography.