Digestion

Digestion 2000;62(suppl 1):45–50

Endoscopic Ultrasonography of Neuroendocrine Tumours

T. Zimmer[a] H. Scherübl[a] S. Faiss[a] U. Stölzel[b] E.-O. Riecken[a]
B. Wiedenmann[c]

Departments of Internal Medicine/Gastroenterology, [a]Klinikum Benjamin Franklin, Freie Universität Berlin; [b]Krankenhaus Döbeln, and [c]Charité, Klinikum Rudolf Virchow, Humboldt Universität Berlin, Germany

Key Words
Neuroendocrine tumour · Insulinoma · Gastrinoma · Endoscopic ultrasonography

Abstract
Neuroendocrine tumours (NETs) of the upper gastrointestinal tract are mainly located in the pancreas, stomach or duodenum. The aims of preoperative work-up are the localization of primary tumour(s), determination of local tumour invasion, of lymph node metastases and of the hormones secreted by the tumour. Endoscopic ultrasonography (EUS) offers ideal conditions to localize and stage NETs of the foregut. We report our results in localizing and staging NETs of the foregut in 40 patients examined between 1990 and 1997 by EUS, somatostatin receptor scintigraphy (SRS), computed tomography (CT), magnetic resonance imaging (MRI) and transabdominal ultrasound (US). EUS shows the highest sensitivity in localizing insulinomas compared with SRS, US, CT and MRI. US and EUS should be the first-line diagnostics if insulinoma has been proven by a fasting test. Further diagnostic procedures are unnecessary in most cases. Further diagnostics such as CT or MRI to search for distant metastases are necessary in large tumours or local invasive tumours. EUS shows the highest accuracy to detect or exclude pancreatic gastrinomas, but fails to detect extrapancreatic gastrinomas in about 50%. The combination of EUS and SRS gives additional information. First-line diagnostics in gastrinoma patients should be SRS and CT or MRI. If no metastases are detected, EUS should be the next preoperative imaging procedure. In nonfunctional NETs, EUS provides the best information on local tumor invasion and regional lymph node involvement.

Introduction

Neuroendocrine tumours (NETs) of the upper gastrointestinal tract are mainly located in the pancreas, stomach or duodenum. The aims of preoperative work-up are the localization of primary tumour(s), determination of local tumour invasion, of lymph node metastases and of the hormones secreted by the tumour. Functional tumours, such as insulinomas and gastrinomas, compromise approximately half of all foregut tumours. The treatment of choice is surgical removal of the tumour [1, 2].

KARGER
Fax + 41 61 306 12 34
E-Mail karger@karger.ch
www.karger.com

0012–2823/00/0625–0045$17.50/0

Accessible online at:
www.karger.com/journals/dig

Thomas Zimmer, MD
Abteilung für Innere Medizin
St. Elisabeth-Krankenhaus
Koblenzer Strasse 91, D–54516 Wittlich (Germany)
Tel. +49 6571 15 1201, Fax +49 6571 15 1218

Due to characteristic neuroglycopenic symptoms, insulinomas are usually diagnosed when still small, resectable and not yet metastatic. Insulinomas are located in the pancreas in almost all cases. Because of small size, localization is the main problem in the preoperative work-up for insulinomas [3].

Gastrinomas are associated with typical clinical symptoms like ulcer disease or gastroesophageal reflux disease. Gastrinomas are metastatic and multilocular in almost half of the cases at the time of diagnosis. More than half of gastrinomas are located extrapancreatic in the duodenal wall or in extraintestinal lymph nodes and are often difficult to detect [4, 5].

Nonfunctional NETs are usually diagnosed by the occurrence of liver metastases or as an incidental finding by endoscopy. In the second case, locoregional staging, especially depth of tumour infiltration into the gastrointestinal wall, is of clinical interest.

Endoscopic ultrasonography (EUS) allows detailed visualization of the whole pancreas and almost all parts of the gastric and duodenal wall with high resolution. The gastrointestinal wall layers and pathological structures as small as 2–3 mm in size can be visualized by EUS. Several studies have shown that EUS is a highly sensitive imaging procedure for pancreatic endocrine tumours, detecting 80–90% of the lesions [6–9], whereas extrapancreatic tumours could be localized with lower sensitivities [10–13].

Here we review the results obtained with EUS in diagnosis of NETs (especially insulinomas and gastrinomas) and give a guideline when to evaluate patients with NETs by EUS.

Techniques of EUS, Patients and Methods

Echoendoscopes, used in the upper gastrointestinal tract, consist in most cases of side-viewing endoscopes with an ultrasonic transducer incorporated into the rigid tip of the instrument. EUS can be performed with two types of ultrasonic scanner:

(1) Endoscopes equipped with a linear scanner or parallel-sector scanner (Pentax FG 32/38): A side-viewing endoscope is combined with a 5- and 7.5-MHz ultrasonic transducer fixed distal to the optics. The section of ultrasound is 105°. Scanning is performed in a plane parallel to the shaft axis of the instrument's tip.

(2) Endoscopes equipped with a radial sector scanner (Olympus GF/JF UM): A side-viewing endoscope is combined with a 7.5- and 12/20-MHz ultrasonic transducer, located distal to the side-viewing optics. The ultrasonic section of 360° is perpendicular to the shaft axis of the instrument's tip.

Patients are examined lying in the left lateral decubitus position. After introducing the echoendoscope into the descending duodenum, ultrasonic examination is performed by withdrawing the instrument. Parts of the gastric and duodenal wall as well as the whole pancreatic area can be visualized with high resolution. Examination of the pancreatic head is performed with a scanner position in the first and second part of the duodenum. Body and tail of the pancreas are investigated with the scanner position in the stomach. A water-filled balloon at the tip of the instrument and filling of the stomach with about 400 ml of water are necessary for fluid interface between the scanner and the gastrointestinal wall.

Patients

Forty patients (female 23, male 17; mean age 49 years, range 8–82) with insulinomas (13), gastrinomas (11) or gastropancreatic nonfunctional NETs (16) were prospectively examined by EUS, somatostatin receptor scintigraphy (SRS), transabdominal ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI) at the Benjamin Franklin Hospital from 1990 until 1997. All patients were screened for hyperparathyroidism by determination of serum calcium and parathyroid hormone levels and for pituitary tumour disease by determination of serum prolactin hormone levels. The various imaging techniques were compared for their diagnostic efficacy in localizing tumours and their metastases. All investigations were carried out within 4 weeks and assessed by maximally two experienced investigators.

Methods

Intraoperative US was performed in patients undergoing surgery. Duodenal transilluminations were done in all gastrinoma patients. However, the latter two methods were not included for evaluation in our study protocol.

EUS examinations were carried out with echoendoscopes, using an ultrasound frequency of 7.5 or 12 MHz and scanning in a plane perpendicular to the shaft axis of the endoscope (GF-UM 3/20, Olympus). The transabdominal US examinations were done using mechanical sector scanners and a sound frequency of 3.5 or 5 MHz (LSC 7000, Picker). CT examinations were performed after oral and intravenous bolus contrast application (Somatom DRH, Siemens, Erlangen, Germany). The total abdomen was examined in 8-mm and the pancreatic region in 4-mm planes. MRI examinations were done with a 1.5-Tesla (Magnetom GBSII, Siemens) in 8-mm-thick transverse sections using 3 pulse sequences. T_1-weighted (SE 500/15), T_2-weighted (SE 2.300/90) and fast T_1-weighted (GRE 160/5/80°) spin-echo sequences were used. The SRS examinations were carried out after an intravenous bolus of 100–200 MBq ^{111}In-labeled pentetreotide (Octreoscan 111, Mallinckrodt Diagnostica, Petten, The Netherlands). Planar images were recorded with a large-field-view gamma camera (Orbiter 7500, Siemens) equipped with a 360-keV parallel-hole collimator. All patients underwent anterior and posterior whole-body static scintigraphy. Planar images were obtained 4, 24, and in selected cases, 48 h after injection of the radioligand. Single-photon emission computed tomography (SPECT) was performed 24 h after injection. SPECT (360° rotation in 32 min, matrix 64 × 64), was done using a Sopha DS 7 camera (Sopha Medical, Frankfurt am Main, Germany) with a medium-energy parallel-hole general-purpose collimator; images were reconstructed with filtered back projection and Chang correction in 6.7-mm slices. Digital (planar) images were analyzed quantitatively by the region-of-interest method. Data were not corrected for transmission absorption or self-attenuation. Liver uptake was calculated from the anterior view, whereas uptakes of the spleen and kidneys were calculated from the posterior view. This technique has previously been described in detail [14, 15].

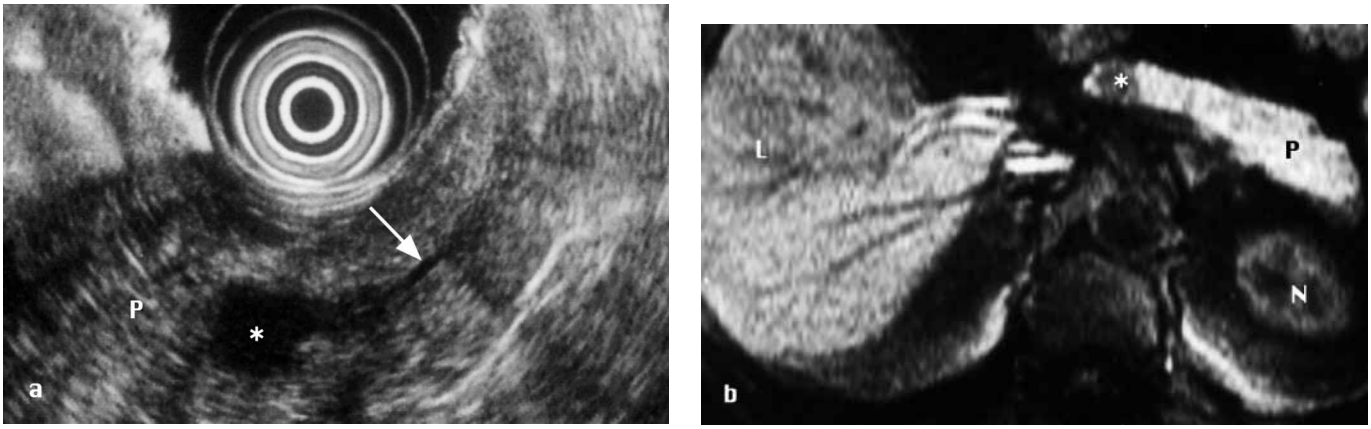

Fig. 1. Insulinoma (*) located in the body of the pancreas imaged by EUS (**a**) and MRI (**b**). P = Pancreas, L = liver, N = left kidney.

Results

Seventeen neuroendocrine tumour lesions were histologically verified in 13 insulinoma patients. All tumours were intrapancreatic. The mean tumour diameter was 1.7 cm. Two female patients had a malignant insulinoma with liver metastases. The primary lesion as well as the liver metastases of these 2 patients could be confirmed by biopsy. In 1 patient with evidence of multiple endocrine neoplasia type I (MENI), 5 tumours were surgically confirmed.

The location of 16/17 tumours could be visualized using EUS (sensitivity 94%). Only 2/17 tumours could be localized by SRS and US (sensitivity 12%), 5/17 by CT (sensitivity 29%), and 2/16 by MRI (sensitivity 13%). Eight of 17 insulinoma lesions (47%) could only be localized by EUS. Endosonographically, 11 of 13 visualized insulinomas displayed a hypoechoic (compared to the pancreas parenchyma), homogeneous inner structure and mostly a smooth delineation (fig. 1).

A total of 15 separate primary tumour lesions were histologically confirmed in 11 gastrinoma patients. Nine tumours were situated intrapancreatically (head 7, body 1, tail 1), 4 in the duodenal wall, 1 in a juxtaduodenal lymph node and 1 intrahepatically. None of the gastrinoma patients showed evidence of MENI. Four patients had two gastrinoma lesions and 7 patients had one lesion, respectively. The mean tumour diameter was 2.0 cm (pancreas 2.1 cm, duodenal 1.6 cm). Four patients had a malignant tumour with infiltration of the portal vein (1), the superior mesenteric vein (1) and liver metastases (2).

13/15 tumours (sensitivity 87%) could be visualized with SRS. 12/15 tumours could be localized by EUS (sensitivity 80%) and 4/15 by US, CT and MRI (sensitivity 27%), respectively. The smallest tumours visualized by EUS were an 8-mm tumour of the duodenal wall and a 5-mm tumour in the pancreatic head. Ten of 15 gastrinoma lesions (66%) were identified only by EUS and SRS. All patients were operated and all 15 tumours could be staged by surgical and pathological examination. 83% of tumours were found to have been staged correctly by EUS.

The visualized duodenal tumours were endosonographically restricted to the middle hyperechoic layer (submucosal layer) (fig. 2). Endosonographically, 8 of the 12 visualized gastrinomas displayed a hypoechoic (compared to the pancreas parenchyma), homogeneous inner structure and a smooth delineation (fig. 2). Only 3 gastrinomas with a tumour diameter of >3 cm had an inhomogeneous, hyperechoic inner structure with hypoechoic to nonechoic parts and were irregularly demarcated.

A total of 21 separate primary tumour lesions were histologically confirmed in 16 patients with nonfunctional gastropancreatic NETs. Nine tumours were situated intrapancreatically (head 5, body 3, tail 1), 8 in the gastric and 4 in the duodenal wall (duodenal 2, papilla major 1, papilla minor 1). None of the patients showed evidence of MENI. The mean tumour diameter was 1.8 cm (pancreas 3.1 cm, duodenal 0.9 cm, gastric 0.7 cm).

18/21 tumours (sensitivity 86%) could be visualized with EUS. 10/21 tumours could be localized by SRS (48%), 8/21 by CT (38%), 5/20 by MRI (25%) and 6/21 by US (29%). Eleven patients were operated and 13 tumours could be staged by surgical or by pathological examina-

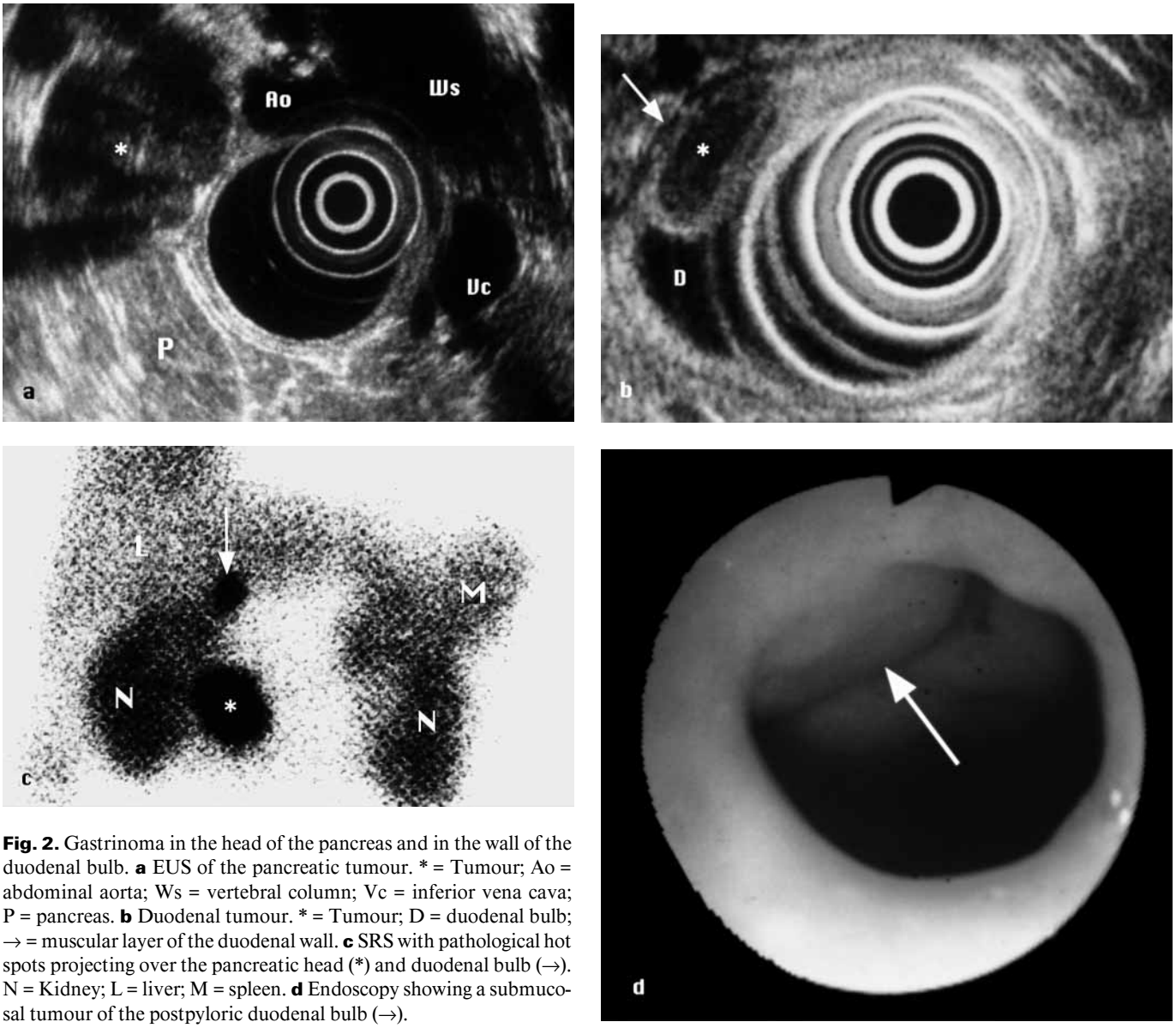

Fig. 2. Gastrinoma in the head of the pancreas and in the wall of the duodenal bulb. **a** EUS of the pancreatic tumour. * = Tumour; Ao = abdominal aorta; Ws = vertebral column; Vc = inferior vena cava; P = pancreas. **b** Duodenal tumour. * = Tumour; D = duodenal bulb; → = muscular layer of the duodenal wall. **c** SRS with pathological hot spots projecting over the pancreatic head (*) and duodenal bulb (→). N = Kidney; L = liver; M = spleen. **d** Endoscopy showing a submucosal tumour of the postpyloric duodenal bulb (→).

tion. 82% of tumours visualized were staged correctly by EUS, 70% by CT, 50% by MRI and 33% by US.

The visualized papilla tumours were hypoechoic and endosonographically restricted to the middle hyperechoic layer (submucosal layer). Gastric and duodenal wall tumours were also hypoechoic and mostly well demarcated. ECLomas in patients with hypergastrinemia were restricted to the mucosal or submucosal layers, duodenal tumours to the submucosal layer. Only one gastric tumour without hypergastrinemia infiltrated all gastric layers and reached the serosal layer. Small pancreatic tumours were hypoechoic, homogeneous and smooth delineated, but large tumours had an inhomogeneous, hyperechoic inner structure with hypoechoic to nonechoic parts and were irregularly demarcated.

Discussion

The high sensitivity of EUS in the localization of insulinomas confirms the results of other studies reporting sensitivities of 57–92% (table 1) [6–10, 16–20]. The sensi-

Table 1. Results of various studies in localizing insulinomas

Method	Sensitivity mean, %	Sensitivity range, %
US	43 (15)	0–63
CT	32 (38)	0–73
MRI	48 (17)	0–100
EUS	75 (92)	57–92
SRS	51 (15)	0–53
Angiography	54	20–86
Calcium provocation	88	75–100
Portal venous sampling	83	75–100
Intraoperative US	89	69–100
Surgical palpation	82	42–100

Results in parentheses represent UKBF in localizing sporadic insulinomas in 13 patients.

Data are from 6–10, 16–20.

Table 2. Results of various studies in localizing gastrinomas

Method	Sensitivity mean, %	Sensitivity range, %
US	22 (27)	6–71
CT	38 (27)	4–100
MRI	31 (27)	20–100
EUS	67 (80)	40–100
SRS	74 (87)	48–100
Angiography	44	0–80
Secretin	83	54–100
Portal venous sampling	76	17–100
Intraoperative US	52	26–83
Surgical palpation	78	42–100
Endoscopic transillumination	70	64–83
Endoscopy	42 (25)	38–45

Results in parentheses represent UKBF in localizing gastrinomas in 11 patients without MENI. Data are from 8–10, 23–32.

tivity of EUS thus compares favourably with that of more invasive procedures such as exploratory laparotomy with palpation and surgical US [21]. Moreover, EUS plays a special role in patients with MENI, who frequently have multiple intrapancreatic tumours that are often not detected by US, CT or other invasive procedures [22].

In contrast to gastrinomas, insulinomas are less sensitively detected by SRS. Up to 50% of all insulinomas were reported to be detected by SRS [23] (table 1). In our hands, SRS was less sensitive (12% sensitivity).

Published results of the various imaging methods for gastrinoma localization are consistent with our results and show sensitivities of about 70% for EUS and 75% for SRS (table 2) [8–10, 23–32]. Results of EUS in detecting duodenal gastrinomas show sensitivities of only 50%. The generally small duodenal gastrinomas can be intraoperatively visualized in about 60–90% by palpation, transduodenal illumination and in all cases by direct exploration of the duodenum after duodenotomy [33, 34]. To find such small tumours, an exact surgical exploration of the duodenum, liver and pancreas must be performed in combination with intraoperative US and duodenal transillumination.

Apart from localizing primary lesions, SRS is also extremely valuable for detecting further primary lesions and metastases, not revealed by CT and US [30–32].

Summary and Conclusions

EUS shows the highest sensitivity in localizing insulinomas compared with SRS, US, CT and MRI. Only invasive methods such as portal venous sampling, surgical palpation or intraoperative US reach similar sensitivities. US and EUS should be the first-line diagnostics if insulinoma has been proven by a fasting test. Further diagnostic procedures are unnecessary in most cases. If EUS fails to localize an insulinoma, despite a positive (correctly performed) fasting test, patients should be operated and be evaluated by intraoperative US and surgical palpation. Further diagnostics such as CT or MRI to search for distant metastases are necessary in large tumours or local invasive tumours.

EUS shows the highest accuracy to detect or exclude pancreatic gastrinomas, but fails to detect extrapancreatic gastrinomas in about 50%. Results of EUS are comparable with SRS in gastrinoma patients, but the combination of both gives additional information.

First-line diagnostics in gastrinoma patients should be SRS, CT or MRI to detect primary tumour lesion and to exclude distant metastases (e.g. liver). If no metastases are detected, EUS should be the next preoperative imaging procedure. During operation, intraoperative US, endoscopic transillumination and surgical palpation should be performed in all cases.

In nonfunctional NETs, EUS provides the best information on local tumor invasion and regional lymph node involvement. In metastatic nonfunctional NETs, EUS is helpful to detect or exclude pancreatic tumours, but the findings are usually without therapeutic consequence.

References

1 Broughan TA, Leslie JD, Soto JM, Hermann RE: Pancreatic islet cell tumors. Surgery 1986; 99:671–678.
2 Fraker DL, Norton JA: The role of surgery in the management of islet cell tumors; in Jensen RT (ed): Gastrointestinal Endocrinology. Gastroenterol Clin North Am 1989;18:805–830.
3 Delvalle J, Yamada T: Secretory tumors of the pancreas; in Sleisinger MH, Fordtran JS (EDS): Gastrointestinal Disease: Pathophysiology, Diagnosis, Management, ed 4. Philadelphia, Saunders, 1989, pp 1884–1900.
4 Ellison EH, Wilson SD: The Zollinger-Ellison syndrome: Re-appraisal and evaluation of 260 registered cases. Ann Surg 1964;160:512–530.
5 Pipeleers-Marichal M, Somers G, Willems G, Foulis A, Imrie C, Bishop AE, Polak JM, Path FRC, Häcki WH, Stamm B, Heitz U, Klöppel G: Gastrinomas in the duodenums of patients with multiple endocrine neoplasia type 1 and the Zollinger-Ellison syndrome. N Engl J Med 1990;322:723–727.
6 Glover JR, Shorvon PJ, Lees WR: Endoscopic ultrasound for localisation of islet cell tumours. Gut 1992;33:108–110.
7 Ligthdale CJ, Botet JF, Woodruff JM, Brennan M: Localization of endocrine tumors of the pancreas with endoscopic ultrasonography. Cancer 1991;68:1815–1820.
8 Palazzo L, Roseau G, Salmeron M: Endoscopic ultrasonography in the preoperative localization of pancreatic endocrine tumors. Endoscopy 1992;24(suppl 1):350–353.
9 Rösch T, Lightdale CJ, Botet JF, Boyce GA, Sivak MV, Yasuda K, Heyder N, Palazzo L, Dancygier H, Schusdziarra V, Classen M: Localization of pancreatic endocrine tumors by endoscopic ultrasonography. N Engl J Med 1992;326:1721–1726.
10 Thompson NW, Czako PF, Fritts LL, Bude R, Bansal R, Nostrant TT, Scheiman JM: Role of endoscopic ultrasonography in the localization of insulinomas and gastrinomas. Surgery 1994; 116:1131–1138.
11 Ruszniewski P, Amouyal P, Amouyal G, Grange JD, Mignon M, Bouche O, Bernades P: Localization of gastrinomas by endoscopic ultrasonography in patients with Zollinger-Ellison syndrome. Surgery 1995;117:629–635.
12 Ruszniewski P, Amouyal P, Amouyal G, Cadiot G, Mignon M, Bernardes P: Endocrine tumors of the pancreatic area: Localization by endoscopic ultrasonography; in Mignon M, Jensen RT (eds): Endocrine Tumors of the Pancreas. Front Gastrointest Res. Basel, Karger, 1995, vol 23, pp 258–267.
13 de Kerviler E, Cadiot G, Lebtahi R, Faraggi M, Le Guludec D, Mignon M: Somatostatin receptor scintigraphy in forty-eight patients with the Zollinger-Ellison syndrome. Eur J Nucl Med 1994;21:1191–1197.
14 Zimmer T, Ziegler K, Bäder M, Fett U, Hamm B, Riecken EO, Wiedenmann B: Localisation of neuroendocrine tumours of the upper gastrointestinal tract. Gut 1994;35:471–475.
15 Scherübl H, Bäder M, Fett U, Hamm B, Schmidt-Gayk R, Koppenhagen K, Dop M, Riecken EO, Wiedenmann B: Somatostatin receptor imaging of neuroendocrine gastroenteropancreatic tumors. Gastroenterology 1993; 105:1705–1709.
16 Bansal R, Kochman ML, Bude R, Nostrant TT, Elta GH, Thompson NW, Scheiman JM: Localization of neuroendocrine tumors utilizing linear-array endoscopic ultrasonography. Gastrointest Endosc 1995;42:76–79.
17 Meyenberger C, Bertschinger P, Zala GF, Marincek B: Endosonography in diagnosis of insulinoma. Ultraschall Med 1995;16:224–227.
18 Schumacher B, Lübke HJ, Frieling T, Strohmeyer G, Starke AAR: Prospective study on the detection of insulinomas by endoscopic ultrasonography. Endoscopy 1996;28:273–276.
19 Pitre J, Soubrane O, Palazzo L, Chapuis Y: Endoscopic ultrasonography for the preoperative localization of insulinomas. Pancreas 1996;13:55–60.
20 De Angelis C, Repici A, Arena V, Pellicano R, Rizzetto M: Preoperative endoscopic ultrasonography in decision-making and management for pancreatic endocrine tumors: A 6-year experience. Endoscopy 1998;30(suppl 1):182–186.
21 van Heerden AJ, Grant CS, Czako PF, Service FJ, Charboneau JW: Occult functioning insulinomas: Which localizing studies are indicated? Surgery 1992;112:1010–1015.
22 Galiber AK, Reading CC, Charboneau JW, Sheedy PF, James EM, Gorman B, Grant CS, van Heerden JA, Telander RL: Localization of pancreatic insulinoma: Comparison of pre- and intraoperative US with CT and angiography. Radiology 1988;166:405–408.
23 Krenning EP, Kwekkeboom DJ, Oei HY, de Jong RJB, Dop JF, Reubi JC, Lamberts SWJ: Somatostatin receptor scintigraphy in gastroenteropancreatic tumors: An overview of European results. Ann NY Acad Sci 1994;33: 416–424.
24 Höring G, Räth U, Rücker S, von Gaisberg U, Meincke J, Walendzik J, Dörr U, Bihl H: Somatostatinrezeptor-Szintigraphie in der Primärdiagnostik und Nachsorge bei Gastrinomen. Dtsch Med Wochenschr 1994;119:367–374.
25 Cadiot G, Lebtahi R, Sarda L, Bonnaud G, Marmuse JP, Vissuzaine C, Ruszniewski P: Preoperative detection of duodenal gastrinomas and peripancreatic lymph nodes by somatostatin receptor scintigraphy. Gastroenterology 1996;111:845–854.
26 Modlin IM, Cornelius E, Lawton GP: Use of an isotopic somatostatin receptor probe to image gut endocrine tumors. Arch Surg 1995;130: 367–373.
27 Ruszniewski P, Amouval P, Amouval G, Grange JD, Mignon M, Bouche O, Bernades P: Localization of gastrinomas by endoscopic ultrasonography in patients with Zollinger-Ellison syndrome. Surgery 1995;117:629–635.
28 Schirmer WJ, Melvin WS, Rush RM, O'Dorisio TM, Pozderac RV, Olsen JO, Ellison EC: Indium-111-pentetreotide scanning versus conventional imaging techniques for the localization of gastrinoma. Surgery 1995;118:1105–1113.
29 Weinel RJ, Kisker O, Joseph K, Welcke U, Zaraca F, Rothmund M: Somatostatin receptor scintigraphy in preoperative diagnosis of the site of endocrine gastrointestinal tumors. Chirurg 1994;65:849–855.
30 Alexander HR, Fraker DL, Norton JA, Bartlett DL, Tio L, Benjamin SB, Doppman JL, Goebel SU, Serrano J, Gibril F, Jensen RT: Prospective study of somatostatin receptor scintigraphy and its effect on operative outcome in patients with Zollinger-Ellison syndrome. Ann Surg 1998;228:228–238.
31 Termanini B, Gibril F, Reynolds JC, Doppman JL, Chen CC, Stewart CA, Sutliff VE, Jensen RT: Value of somatostatin receptor scintigraphy: A prospective study in gastrinoma of its effect on clinical management. Gastroenterology 1997;112:335–347.
32 Gibril F, Reynolds JC, Doppman JL, Chen CC, Venzon DJ, Termanini B, Weber C, Stewart CA, Jensen RT: Somatostatin receptor scintigraphy: Its sensitivity compared with that of other imaging methods in detecting primary and metastatic gastrinomas. Ann Intern Med 1996;125:26–34.
33 Frucht HF, Norton JA, London JF, Vinayek R, Doppman JL, Gardner JD, Jensen RT, Maton PN: Detection of duodenal gastrinomas by operative endoscopic transillumination. Gastroenterology 1990;99:1622–1627.
34 Sugg SL, Norton JA, Fraker DL, Metz DC, Pisegna JR, Fishbeyn V, Benya RV, Shawker TH, Doppman JL, Jensen RT: A prospective study of intraoperative methods to diagnose and resect duodenal gastrinomas. Ann Surg 1993;218:138–144.