# Minimally Invasive Techniques for Resection of Pancreatic Neuroendocrine Tumors

Gustavo G. Fernandez Ranvier, MD[a], Daniel Shouhed, MD[a], William B. Inabnet III, MD[b,*]

**KEYWORDS**

• Pancreatic neuroendocrine tumors • Insulinoma • Gastrinoma
• Laparoscopic pancreas resection • Robotic pancreas resection

**KEY POINTS**

- Surgical resection is the only curative treatment of pancreatic neuroendocrine tumors (PNETs).
- Minimally invasive procedures are a safe modality for the surgical treatment of PNETs.
- Laparoscopy does not compromise oncologic resection, and is associated with decreased postoperative pain, better cosmetic results, a shorter hospital stay, and a shorter postoperative recovery period.
- The overall 5-year and 10-year survival rates for all PNETs are approximately 65% and 45%, respectively.

## INTRODUCTION

Pancreatic neuroendocrine tumors (PNETs) are a heterogeneous group of neoplasms that have an incidence of 1 per 100,000 individuals per year, and account for 1% to 2% of all pancreatic neoplasms.[1,2] PNETs can develop at any age, but they are more frequently seen in patients between the fourth and sixth decades of life. Although most tumors are considered sporadic, about 10% to 30% of cases present in patients with familial syndromes such as multiple endocrine neoplasia type 1 (MEN1),von

Disclosures: The authors have nothing to disclose.

[a] Division of Metabolic, Endocrine and Minimally Invasive Surgery, Department of Surgery, Mount Sinai Hospital, Icahn School of Medicine at Mount Sinai, 5 East 98 street, box 1259, New York, NY 10029, USA; [b] Department of Surgery, Mount Sinai Beth Israel, Icahn School of Medicine at Mount Sinai, First Ave at 16th street, Baird Hall, Suite 16BH20, New York, NY 10003, USA
* Corresponding author.
*E-mail address:* william.inabnet@mountsinai.org

Surg Oncol Clin N Am 25 (2016) 195–215
http://dx.doi.org/10.1016/j.soc.2015.08.009 **surgonc.theclinics.com**
1055-3207/16/$ – see front matter 

Hippel-Lindau, neurofibromatosis type 1, and tuberous sclerosis, among other more rare syndromes.[3] PNETs can be classified into functional and nonfunctional tumors. Functional tumors are usually detected early because of the symptoms caused by hormonal production. Nonfunctional tumors are more common, but given the absence of hormonal symptoms these tumors are found incidentally or in more advanced stages of the disease, with larger tumors causing mass effect, invading surrounding tissues or presenting with metastatic disease.[4,5]

Surgical resection of the primary tumor remains the treatment of choice for PNETs, because it is associated with increased survival.[4] With the advancement of minimally invasive techniques, an increasing number of laparoscopic surgical resections for pancreatic neuroendocrine tumors are currently performed.[6] Low-risk PNETs in the body and the tail of the pancreas are suitable for minimally invasive surgery, with enough evidence in the literature supporting better outcomes of the laparoscopic approach compared with open surgery.[6,7] However, minimally invasive pancreatic surgery has not yet been widely accepted as the gold standard for all pancreatic resections. Most recently, robotic surgical techniques across different specialties have slowly gained popularity, although the existing experience is only based on reports of small series.[8–12] This article provides an insight into well-established minimally invasive procedures and also those that slowly have gained popularity over the last few years. It also reviews and discusses the different minimally invasive surgical techniques with their benefits and limitations.

## DIAGNOSIS

### *Insulinoma*

Insulinomas are the most common functional neuroendocrine tumors of the pancreas as well as the most common cause of hypoglycemia related to endogenous hyperinsulinemia. Most insulinomas are benign, small (<2 cm) tumors with only 10% of cases usually presenting as malignant lesions. They are typically solitary lesions distributed evenly throughout pancreas, except in association with MEN1 syndrome, when they tend to be multifocal. The clinical signs and symptoms of insulinomas are divided into 2 categories. Neuroglycopenic symptoms, which are a direct result of hypoglycemia, may include weakness, confusion, visual disturbances, and in extreme cases seizures and comas. Autonomic symptoms, which are a consequence of catecholamine release from hypoglycemia, include diaphoresis, palpitations, anxiety, and tremor.[13,14]

Establishing a diagnosis of insulinoma has classically relied on satisfying the criteria of the Whipple triad: (1) hypoglycemia (plasma glucose level <50 mg/dL), (2) neuroglycopenic symptoms, and (3) prompt resolution of symptoms following administration of glucose.[15] At present, biochemical measurement of plasma glucose, insulin, C peptide, and proinsulin levels during a 72-hour fast can detect up to 99% of insulinomas and has become the gold standard of diagnosis.[16] However, in more than 97% of cases, biochemical testing in conjunction with a supervised 48-hour fast is sufficient to diagnose an insulinoma.[17] Other conditions, such as the factitious use of insulin or oral hypoglycemic agents, can be ruled out through the measurements of plasma proinsulin, C peptide, and sulfonylurea.

### *Gastrinoma*

Gastrinomas, along with insulinomas, account for most functional PNETs. Most of these tumors are found sporadically, although 20% to 30% are found in conjunction with MEN1. They are the most common pancreatic tumor found in patients with MEN1.[18] Gastrinoma syndrome, also known as Zollinger-Ellison syndrome, has a