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Advancements in Medical Treatment for Pancreatic Neuroendocrine Tumors: A Beacon of Hope

Medical Treatment for Pancreatic Neuroendocrine Tumors

Somdatta Giri, Jayaprakash Sahoo

Abstract

This editorial highlights the remarkable advancements in medical treatment strategies for pancreatic neuroendocrine tumors (pan-NETs), emphasizing tailored approaches for specific subtypes. Cytoreductive surgery and somatostatin analogs (SSAs) play pivotal roles in managing tumors, while palliative options such as molecular targeted therapy, peptide receptor radionuclide therapy, and chemotherapy are reserved for SSA-refractory patients. Gastrinomas, insulinomas, glucagonomas, carcinoid tumors and VIPomas necessitate distinct therapeutic strategies. Understanding the genetic basis of pan-NETs and exploring immunotherapies could lead to promising avenues for future research. This review underscores the evolving landscape of pan-NET treatment, offering renewed hope and improved outcomes for patients facing this complex disease.

Key Words: Pancreatic neuroendocrine tumour; Medical management; Somatostatin analogue; Immunotherapy; Everolimus

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Core Tip: The evolving landscape of pancreatic neuroendocrine tumor (pan-NET) treatment showcases tailored approaches based on tumor subtype. Cytoreductive surgery and somatostatin analogs are pivotal, but peptide receptor radionuclide therapy and molecular targeted agents are promising treatments for refractory cases. Understanding genetic markers and exploring immunotherapies open promising avenues for future research.

INTRODUCTION

Pancreatic neuroendocrine tumors (pan-NETs) present unique challenges in the field of oncology. These tumors account for 1–2% of all pancreatic cancers and are mostly sporadic. Sometimes, pan-NETs are associated with various syndromes, such as multiple endocrine neoplasia 1 (MEN1), von Hippel–Lindau (VHL) disease, tuberous sclerosis or neurofibromatosis. Often, these tumors are diagnosed at an advanced stage during the course of disease with metastasis to multiple organs, decreasing the success of curative surgery. The role of medical therapy is as follows.

Pancreatic neuroendocrine tumors

Most patients with advanced pan-NETs (50-75%) have nonfunctioning tumors and do not have any associated hormonal syndrome. Somatostatin analogs (SSAs) provide a valuable palliative option by reducing hormonal secretion as well as the tumor burden. The European Neuroendocrine Tumor Society (ENETS), North American Neuroendocrine Society (NANETS), and National Comprehensive Cancer Network (NCCN) suggest the initiation of SSA in patients with unresectable, asymptomatic, well-differentiated pan-NETs and a high tumor burden, as SSAs have been shown to improve survival in the PROMID[1] and CLARINET trials[2]. Treatment of highly symptomatic patients may be initiated with short-acting octreotide in combination with rapid transition to a long-acting formulation (LAR) and subsequent titration of the dose to optimize symptom control while the LAR formulation is starting to take effect (approximately 10-14 days). The depot preparation, *e.g.*, octreotide LAR, has largely eliminated the need for daily octreotide injections. Patients may use additional short-

acting octreotide for breakthrough symptoms while doses are being titrated. Lanreotide can be administered once monthly via deep subcutaneous injection and appears to have efficacy similar to that of octreotide.

Notably, molecular targeted therapies, peptide receptor radionuclide therapy (PRRT), and chemotherapy are typically reserved for patients refractory to SSAs[3]. According to recent European Society of Medical Oncology (ESMO) guidelines, the mammalian target of rapamycin complex (mTOR) inhibitor everolimus is recommended for the treatment of G1/G2 pan-NETs[4]. A good treatment effect of everolimus was also recorded irrespective of the volume of liver metastasis in the RADIANT-4 trial[5]. Everolimus in combination with SSAs in advanced and metastatic pan-NETs demonstrated greater benefit than everolimus monotherapy in the RADIANT-1 and RADIANT-3 trials. In contrast to these data, the combination of everolimus with pasireotide did not prove to exert any further benefit. Everolimus should be carefully coadministered with glucocorticoids since, in the RADIANT-3 cohort, their combination resulted in a fatal episode of acute respiratory distress, as everolimus can cause immunosuppression. The progression-free survival (PFS) associated with the combination of everolimus and metformin was better than that associated with everolimus alone[6]. The mechanisms affected by metformin include a reduction in blood glucose, insulin, and IGF-1 Levels; inhibition of mitochondrial oxidation; activation of AMP-activated protein kinase (AMPK); and antibacterial cell autonomy *via* mTOR inhibition as well as oncogenic effects.

PRRT has emerged as a beacon of hope for patients with metastatic but low-grade pan-NETs where curative surgery is not possible. This targeted therapy utilizes radionuclides to deliver systemic treatment. In the NETTER-1 trial, patients who received 177Lu-DOTATATE with SSA experienced a 54.4% increase in estimated PFS at 20 months *vs* SSA alone[7].

On the other hand, neuroendocrine carcinoma (NEC) is genetically more similar to pancreatic cancer than to G1/G2 NETs. The role of chemotherapy is as follows. Capecitabine acts in combination with temozolomide, perhaps by downregulating the

DNA repair enzyme methylguanine methyltransferase (MGMT). Although combined therapy is more effective for treating pancreatic NETs, overall survival in patients with NEC is not good (22 *vs.* 4.6 months)[8]. In NEC patients, cisplatin-based therapy with etoposide or irinotecan remains the standard first-line chemotherapy option[9]. The results of these studies related to the management of pan-NETs are summarized in **Table 1**.

Gastrinomas

In gastrinomas, where surgical intervention might pose significant risks, high-dose proton pump inhibitor therapy (PPI) with or without SSAs can effectively control symptoms and tumor growth. Patients without imageable pancreatic tumors in MEN1 exhibit promising survival rates, i.e., 5-year survival rates of approximately 90% and a 10-year survival rate of 54% in patients with disseminated distant metastasis, underscoring the importance of tailored approaches [10]. Long-acting PPIs such as omeprazole 60 mg a day or an equivalent dose of other PPIs once or twice a day are durable and effective in patients with sporadic gastrinoma without evidence of tachyphylaxis. The goal of PPI therapy is to restrict basal acid output to <10 mEq/h during the hour before the next dose. Patients with MEN1-related gastrinoma may require a daily dose of 80-120 mg of omeprazole. Effective treatment of hypercalcemia in MEN1 patients is of paramount importance because it reduces gastric acid hypersecretion. It is advised to continue PPI therapy for at least 3-6 months after resection of the tumor due to the continued risk of gastroesophageal reflux disease complications caused by the increased parietal cell mass. Vigilance is required for potential side effects of long-term PPI therapy, such as vitamin B12 deficiency, hypomagnesemia and the risk of bone fracture. The role of SSA in PPI refractory patients was well documented in a retrospective study of 12 patients with gastrinoma[11]. In this study, all but one patient achieved complete clinical control with octreotide or lanreotide.

Insulinomas

Insulinomas present a unique challenge, as patients develop hypoglycemia. Diazoxide (50-600 mg daily) is the primary medical therapy, and in refractory cases, glucocorticoids, verapamil, and diphenylhydantoin may be considered. SSAs can reduce insulin levels and are pivotal for the antiproliferative control of well-differentiated tumors. Since there is usually low expression of somatostatin receptor type 2 (SSTR2) in benign insulinomas, SSA therapy may result in paradoxical worsening of hypoglycemia, as it also decreases glucagon secretion. In contrast, advanced insulinomas usually express SSTR2 and SSTR5. The pans omatostatin receptor agonist pasireotide is a promising option for patients with refractory hypoglycemia, especially for those with metastatic insulinoma[12]. Everolimus has both antineoplastic and antisecretory effects as shown in **Figure 1** and has been successfully tested for refractory insulinoma[13]. However, exhaustion of its antineoplastic effect is observed after 2 years due to downregulation of mediators involved in the mTOR pathway instead of true resistance[14]. Therefore, rechallenge with everolimus can be considered since this phenomenon appears to be transient.

Glucagonomas

For glucagonomas, SSAs are considered first-line treatments, as they have shown remarkable efficacy in controlling hormonal symptoms. In advanced cases, management must include SSAs to improve patient performance status, enabling surgical options to be considered[14]. Amino acid infusion and zinc therapy have shown promise in improving skin lesions associated with necrolytic migratory erythema.

VIPoma

VIPoma can cause severe and life-threatening diarrhea. Supportive care with intravenous fluids and electrolytes is crucial. SSAs have shown substantial promise in improving VIPoma-associated symptoms. Chemotherapy and sunitinib improved diarrhea in 10 out of 12 patients in a French study. Hypercalcemia associated with

VIPoma is caused by the secretion of parathyroid hormone-related proteins and responds well to both zoledronate and denosumab[15].

Carcinoid syndrome

Management of crisis due to carcinoid syndrome is a medical emergency that requires the infusion of octreotide along with serotonin antagonists such as ondansetron, cyproheptadine, and ranitidine. A bolus of octreotide 100–500 µg should be immediately administered, followed by a maintenance dose of 50–100 µg/h (maximum 500 µg/h). Sympathomimetics can precipitate hormonal release by the tumor, paradoxically leading to distributive shock, and should be used cautiously. However, if a patient needs to be on sympathomimetics, the selective alpha1-agonist phenylephrine and vasopressin are the preferred vasopressors in this context.

As prophylaxis for carcinoid crisis, SSA can be started before surgery or before PRRT. The SSA-free period before the start of PRRT should be kept as short as possible (8-24 h), and the safe reintroduction of SSA 1 h after the infusion of ^{177}Lu-DOTATATE should be avoided to prevent functional symptom deterioration due to the release of hormones following PRRT. Antidiarrheal agents such as loperamide are also useful. However, refractory diarrhea responds well to telotristat, a tryptophan hydroxylase inhibitor [16]. Patients with niacin deficiency or pellagra should be started on nicotinamide. A simplified flow diagram showing approach to medical therapy in Pan-NETs is depicted in **Figure 2**.

Future medical therapy in pan-NETs

Elucidating the genetic underpinnings of different pan-NET subtypes opens new avenues for tailored therapies. Mutations in genes such as *DAXX/ATRX, EPHB4, ROS1,* and *KMT2A* provide potential targets for future research[17]. Compared to NETs of extrapancreatic origin, pan-NETs have higher expression levels of programmed cell death protein 1 (PD-1) and more tumor-infiltrating lymphocytes[18]. Immunotherapies,

particularly PD-1 inhibitors, in combination with anti-vascular endothelial growth factor (bevacizumab) have shown potential in controlling pan-NETs.

CONCLUSION

The landscape of pan-NET treatment has evolved significantly, offering patients a more tailored and effective approach. From surgical interventions to targeted therapies and immunomodulatory agents, advancements in medical treatment for pan-NETs represent a beacon of hope for those facing this challenging disease. As research continues to uncover the intricacies of this condition, we can look forward to even more promising developments in the future.

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