ABSTRACT

Introduction  The management of small pancreatic neuroendocrine neoplasms (PNENs) remains controversial. The standard treatment for PNENs is surgical resection; however, invasiveness of surgical procedure remains higher and the incidence of postoperative adverse events is still high. Recently, the efficacy and safety of endoscopic ultrasonography (EUS)-guided ethanol injection for small PNENs has been preliminarily demonstrated. Thus, a multicentre prospective study is being conducted to evaluate the efficacy and safety of EUS-guided ethanol injection therapy for small PNENs.

Methods and analysis  The major eligibility criteria are the presence of pathologically diagnosed grade (G) 1 tumour, a tumour size of ≤15mm and non-functional PNEN or insulinoma. For treatment, we will use a 25-gauge needle and pure ethanol. Contrast-enhanced CT (CE-CT) will be performed on postoperative day 3–5, and if enhanced areas of the tumour are still apparent, an additional session is scheduled during the same hospitalisation period. We set the total amount of ethanol per session to 2 ml. To evaluate the efficacy and safety, CE-CT will be performed at 1 and 6 months after treatment. The primary endpoint is the percentage of subjects who achieved all of the following evaluated points. Efficacy will be evaluated based on the achievement of complete ablation (defined as no enhanced area within the tumour on CE-CT) at 1 and 6 months. Safety will be evaluated based on the avoidance of severe adverse events within 1 month after treatment, continuing severe pancreatic fistula at 1 month after treatment and the incidence and/or exacerbation of diabetes mellitus at 6 months after treatment.

Ethics and dissemination  This protocol has been approved by Okayama University Certified Review Board (approval number. CRB19-007). The results will be submitted to peer-reviewed journals and will be presented at international conferences.

Trial registration number  jRCTs061200016.

INTRODUCTION

Pancreatic neuroendocrine neoplasms (PNENs) are fairly rare, accounting for 1%–2% of primary pancreatic malignancies. However, the incidence of PNENs has increased substantially because of the widespread use of advanced endoscopic and radiological imaging techniques. The treatment methods for PNENs depend on the hormone-related symptoms and tumour size. For patients with symptomatic disease or tumours of >2 cm in diameter, surgical resection is the standard of care. However, the optimal treatment approach for patients with non-functional, small PNENs (≤2 cm in diameter) is controversial. Sadot et al. reported the outcomes of observation versus resection for small asymptomatic PNENs. In their report, the observation was recommended for 104 patients (observation group), and these patients were matched to 77 patients in a resection group based on tumour size on initial imaging (the median tumour size in the observation and resection...
The advantages of EUS-guided therapy are that the reduction of complications can be expected in comparison to surgical resection and that the pancreatic exocrine and endocrine functions can be preserved. On the other hand, EUS-guided therapy is associated with a limitation. Complete tumour ablation is determined based on thin slice CE-CT findings; however, it is sometimes difficult to demonstrate complete tumour elimination. Furthermore, long-term follow-up is required to prove the efficacy of EUS-guided treatment, and lymph node dissection cannot be performed. Thus, EUS-guided treatment should be limited to patients with a low risk of lymph node metastasis and small tumour size.

Hashim et al reported on the rate of lymph node metastasis of PNENs according to tumour size. They evaluated 136 patients who underwent surgical resection of PNENs with lymph node resection (surgical methods: DP, 54%; PD, 41%; total pancreatectomy, 2%; nuclear excision, 2%). The lymph node metastasis rates were 12% (2/17) in patients with a tumour diameter of ≤10 mm, 14.3% (3/22) in patients with a tumour diameter of 11–15 mm and 40% (8/21) in patients with a tumour diameter of 16–20 mm. A logistic regression analysis was performed to determine factors associated with the frequency of lymph node metastasis: the frequency was higher in patients with larger tumours (>1.5 cm; OR=4.7), tumours of the head (in comparison to pancreatic body-tail (OR=2.8)), tumours with Ki-67 of >20% (OR=6.7) and tumours with lymphovascular invasion (OR=3.6) (p<0.05). Considering the risk of lymph node metastasis, tumour size ≤15 mm and pathologically G1 are suitable for EUS-guided therapy.

Therefore, we launched the current trial to assess the efficacy and safety of EUS-guided ethanol injection therapy for PNENs of <15 mm in size with a pathological diagnosis of G1.

**METHODS AND ANALYSIS**

**Study setting**

This study is conducted as a multicentre, single-arm, prospective, phase II study in six high-volume medical centres in Japan. Eligible patients with a PNEN will be treated by EUS-guided ethanol injection and followed up until 6 months after treatment. An overview of the protocol is shown in figure 1.

**Endpoints**

**Primary endpoint**

This study establishes a composite primary endpoint. The primary endpoint is the percentages of subjects who achieve all of the following evaluated points.

1. **Efficacy:**
   - Complete ablation on CE-CT at 1 and 6 months after treatment
2. **Safety:**
   - Avoidance of severe adverse events within 1 month after treatment
Figure 1  A flow chart of the present study. CE-CT, contrast-enhanced CT; EUS, endoscopic ultrasonography.

- Avoidance of severe pancreatic fistula at 1 month after treatment
- Avoidance of the incidence and/or exacerbation of DM at 6 months after treatment

Secondary endpoints
The following secondary endpoints will be evaluated in two cohorts: Cohort 1 (tumour size ≤10 mm) and Cohort 2 (tumour size 10–15 mm).

1. Safety:
   - Prevalence of total adverse events
   - Prevalence of device failures
   - Prevalence of conversion to surgery
   - Prevalence of severe adverse event within 1 month after procedure
   - Prevalence of severe pancreatic fistula at 1 month after procedure
   - Prevalence of DM exacerbation at 6 months after treatment

2. Efficacy:
   - Complete ablation on CE-CT at 1 month after treatment
   - Complete ablation on CE-CT at 6 months after treatment
   - Six-month overall survival.

The following endpoints will only be evaluated in patients with insulinoma.

1. Improvement of hypoglycaemic symptoms
2. Changes in serum levels of fasting blood glucose, insulin and C peptide from before to after the procedure

Definition
Complete ablation is defined as the absence of enhanced areas within the tumour on arterial phase CE-CT imaging with a slice thickness of 1–2 mm. The CE-CT images will be reviewed independently by two expert gastroenterologists. If it is difficult to make a judgement by CE-CT, CE-EUS will be performed to assess the existence of enhanced areas within the tumour. Procedure-related adverse events will be evaluated based on American Society for Gastrointestinal Endoscopy (ASGE) guideline 2010, and other adverse events will be evaluated based on Common Terminology Criteria for Adverse Event (CTCAE) V.5.0. Severe adverse events are defined as moderate or higher in ASGE and grade 3 or higher in CTCAE. Severe pancreatic fistula is defined as continuing any treatment for pancreatic fistula (percutaneous or endoscopic drainage tube and/or medication) at 1 month after the procedure. DM is defined as a fasting blood glucose level of 126 mg/dL or an occasional blood glucose level of 200 mg/dL and glycated haemoglobin (HbA1c) ≥6.5 (National Glycohemoglobin Standardisation Programme value). New-onset DM means that a patient without DM at the time of registration newly developed DM, and the exacerbation of DM means that a patient who did not meet the definition for DM at the time of registration starts or adds a medication for DM due to poor glycaemic control, or HbA1c is increased up to 0.2%.

Patient eligibility
The eligibility and exclusion criteria are shown in box 1. EUS-guided fine needle aspiration (FNA) will be performed to exclude the possibility of lymph node metastasis. A flow chart of suspicion of lymph node metastasis on CE-CT is shown in figure 2.
The patient is discharged after the last ablation session during the same hospitalisation period.

Follow-up postoperative day 1.

If enhanced areas of the tumour are noted, the maximum volume of ethanol per session is set to 3 mL, and the total number of punctures per session is set to 3, and the maximum volume of ethanol per session is set to 2 mL.

At 3–5 days after the treatment, CE-CT is performed to evaluate the tumour viability and procedure-related adverse events. If enhanced areas of the tumour are noted on postprocedural CE-CT, we will perform an additional ablation session during the same hospitalisation period. The patient is discharged 1 day after this additional session. If there are no enhanced areas of the tumour on postprocedural CE-CT, then the patient is discharged.

Blood testing is performed at 2 hours postoperatively and on postoperative day 1.

Follow-up examinations are scheduled for 1, 3 and 6 months to evaluate the general condition of the patient, and blood testing is performed. The patients are also scheduled to undergo follow-up CE-CT imaging at 1 and 6 months after discharge. When incomplete ablation of the treated lesion is judged to have occurred based on follow-up CE-CT, salvage surgical resection will be considered to the patient.

**Figure 2** A flow chart of the suspicion of lymph node metastasis on CE-CT. CE-CT, contrast-enhanced CT; EUS-FNA, endoscopic ultrasonography-guided fine needle aspiration; LN, lymph node.

**Study procedure**

The procedure is performed with the patient in a prone or semi-prone position under conscious sedation using intravenous anaesthetic in the endoscopy room. For treatment, a 25-G fine-needle aspiration needle (EZ-shot 3; Olympus Medical Systems, Tokyo, Japan) filled with pure ethanol (Mylan Seiyaku, Tokyo, Japan) is injected until a hyperechoic blush extends to the edge of the tumour margin and the needle is kept inside the tumour for at least 1 min to avoid the backflow of ethanol. Once the needle is removed, we check for low-echoic areas of the tumour. If such areas are detected, ethanol is added to the site. For the sake of safety, the amount of ethanol per puncture is set to 1 mL, the total number of punctures per session is set to 3, and the maximum volume of ethanol per session is set to 2 mL.

At 3–5 days after the treatment, CE-CT is performed to evaluate the tumour viability and procedure-related adverse events. If enhanced areas of the tumour are noted on postprocedural CE-CT, we will perform an additional ablation session during the same hospitalisation period. The patient is discharged 1 day after this additional session. If there are no enhanced areas of the tumour on postprocedural CE-CT, then the patient is discharged. Blood testing is performed at 2 hours postoperatively and on postoperative day 1.

**Follow-up**

Follow-up examinations are scheduled for 1, 3 and 6 months to evaluate the general condition of the patient, and blood testing is performed. The patients are also scheduled to undergo follow-up CE-CT imaging at 1 and 6 months after discharge. When incomplete ablation of the treated lesion is judged to have occurred based on follow-up CE-CT, salvage surgical resection will be considered to the patient.

**Patient and public involvement**

No patient involved.

**Sample size calculation**

A historical data set was analysed to evaluate surgical treatment in 23 patients with PNEN (≤15 mm in diameter) who underwent treatment at Okayama University Hospital from November 2007 to January 2018. This data showed that 48% (11/23) of the patients met the composite primary endpoints; the local control rate for target lesion was 100% (23/23), the rate of severe adverse events (Clavien-Dindo grade III-IV) within 1 month after treatment was 35% (8/23), the rate of severe pancreatic fistula at 1 month after treatment was 35% (8/23) and the incidence of DM or the exacerbation of DM at 6 months after treatment was 17% (4/23), respectively. In our previous pilot study of EUS-guided ethanol injection therapy, 75% (6/8) of the patients achieved the composite primary endpoints; the complete ablation rate at 1 and 6 months was 75% (6/8), no patients experienced severe adverse events, no patients developed severe pancreatic fistula and no patients developed DM or experienced an exacerbation of DM. Thus, the null and alternative hypotheses are given below:

\[ H_0: \pi = 0.48 \]
\[ H_1: \pi = 0.75 \]

where \( \pi \) is the anticipated composite primary endpoint after the study procedure. Against abovementioned background, 22 patients would provide a statistical power of 80% to test the primary hypothesis at the two-sided significance level of 0.1. Considering non-compliance and/or dropout patients, 25 patients are recruited in total.

**Statistical analysis**

The data analysis is performed according to an intention-to-treat principle. Clopper-Pearson’s exact binomial test and CI estimation are applied for the primary endpoint and the secondary endpoints. The statistical significance level is set at 10% for the purpose of orphan disease regulatory filing, otherwise 5% (two-sided). All analyses are conducted with SAS software (SAS Institute).

**ETHICS AND DISSEMINATION**

Written informed consent from all the patients screened will be obtained before the procedures start. The study protocol has been approved by Okayama University Certified Review Board (approval number, CRB19-007) and registered in Japan Registry of Clinical Trial. Monitoring and auditing will be carried out throughout the trial. We will also establish an independent data monitoring committee consisting of three additional doctors who were not associated with the study to determine whether or not the study should continue if severe adverse events occur.

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REFERENCES


