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ORIGINAL RESEARCH

Computed Tomography-guided Drainage with Modified Trocar Technique Using a *Drainaway* Drainage Kit

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Abstract:
Purpose: Image-guided percutaneous drainage for abscesses is known as a safe and effective treatment. The computed tomography-guided percutaneous drainage kit *Drainaway* (SB Kawasumi Co., Ltd.), developed on the basis of a modified trocar method, has made it possible to complete the procedure only under computed tomography guidance without radiographic fluoroscopy. This study investigated the feasibility and safety of *Drainaway* for abscess drainage.
Material and Methods: In this retrospective observational study, 28 procedures in 27 patients (18 men and 9 women; age 67.0 ± 12.3 years) who underwent computed tomography-guided drainage using *Drainaway* between March and December 2021 at seven affiliated hospitals were analyzed. Patients with symptomatic, puncturable on computed tomography and refractory abscesses were included. Technical success (successful drainage with computed tomography alone), primary clinical success (successful drainage with *Drainaway* alone), secondary clinical success (avoidance of surgery), and complications were evaluated.
Results: The sites of the abscesses were the intraperitoneal, retroperitoneal, and thoracic cavities in 19, 5, and 2 patients, respectively, and subcutaneous tissue in 1 patient. The mean size of the abscesses was 7.1 ± 3.4 cm. The technical success rate was 96.4%; the ligament of the puncture route could not be penetrated in one case. The primary clinical success rate was 77.8%, whereas the secondary clinical success rate of catheter upsizing or replacement was 96.3%. Complications included one case of biliary pleurisy that required drainage.
Conclusions: *Drainaway* is a useful device that allows abscess drainage using only computed tomography guidance without radiographic fluoroscopy.

Keywords:
abscess drainage, CT-guided drainage, modified trocar technique

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Introduction

Image-guided percutaneous drainage of abscesses is a useful technique for reducing mortality and hospital length of stay and costs [1]. Ultrasound (US)-guided Seldinger puncture and fluoroscopic drain placement have the advantages of real-time confirmation of needle movement and minimization of radiation exposure from the imaging modal-

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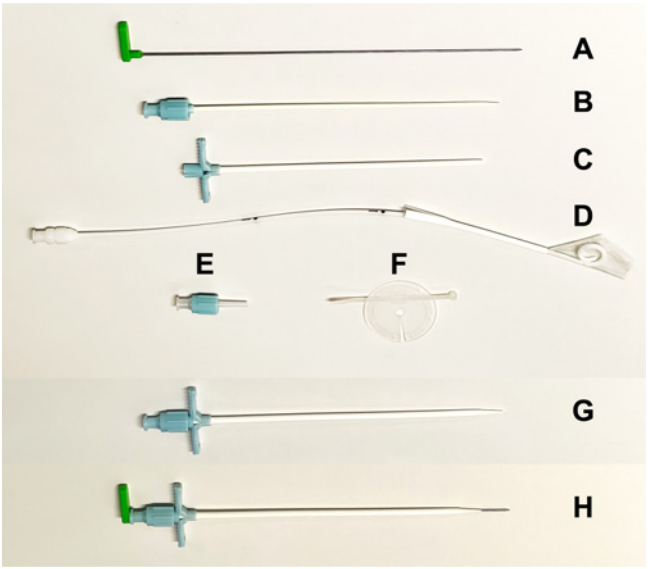

Figure 1. Structure of the *Drainaway* drainage kit.
A: Puncture needle
B: dilator
C: 8-Fr sheath
D: 8-Fr 27-cm pigtail catheter
E: suction connector
F: fixing plate
G: combined dilator and sheath
H: combined puncture needle, dilator, and sheath

ity [2]; however, they often fail to provide a safe puncture path. Computed tomography (CT)-guided percutaneous drainage is a minimally invasive technique that can be used to treat deep abscesses that are difficult to reach using US-guided techniques [2, 3]. Percutaneous drainage can be performed using either the single-step trocar method or the multistep Seldinger method [2]. In CT-guided Seldinger puncture and drain placement, the patient must be moved to a radiographic fluoroscopy room after undergoing CT-guided Seldinger puncture in medical institutions that do not have a combined angiography-CT system; this poses a risk of procedural problems [4]. Performing drain placement using the Seldinger method with CT imaging alone without radiographic fluoroscopy is potentially risky because the drain placement maneuver is temporarily blinded [4]. Additionally, the procedure requires care in keeping needles and wires clean on a narrow CT system and often involve the assistance of a physician. Conversely, CT-guided puncture and drain placement using the trocar method is convenient [5]. However, the drain may break in a bellow shape because of insufficient penetration force or may not fit within the CT gantry because of the system's length. Therefore, there was a need for a medical device that would improve the safety of percutaneous drainage using the trocar method, which is completed only with CT guidance.

Drainaway, a CT-guided drainage kit comprising a 20-gauge needle, peel-away sheath, and an 8-Fr 27-cm drainage catheter (Sumitomo Bakelite Kawasumi Co., Ltd., Tokyo, Japan), supports safe CT-guided percutaneous drainage, which is completed only under CT guidance without the use of radiographic fluoroscopy (**Fig. 1**). The sheath attached to *Drainaway* is 20 cm in length, alleviating concerns about the sheath not fitting into the CT gantry. Additionally, the tip of the sheath is sharp enough to provide a high penetration force but does not penetrate the vessel wall when the inner needle is retracted. It is also possible to adjust the drain position after the sheath is placed in the abscess.

This study aimed to evaluate the feasibility and safety of CT-guided percutaneous drainage using *Drainaway* (modified trocar technique).

Material and Methods

Study design

This retrospective observational study was conducted at a university hospital and six affiliated hospitals. After the research protocol was approved by the ethics committee of the university hospital, anonymized patient data were compiled at the university hospital after obtaining permission from the director of each affiliated institution. Patient consent was waived because of the retrospective study design; however, the details were made public on the institutional bulletin board. The participants were guaranteed the opportunity to refuse to participate in or continue with the study. Consent for the procedure was obtained from all patients or the patient's family if the patient could not provide consent due to impaired consciousness.

Patients and data collection

We analyzed 28 procedures in 27 patients (18 men and 9 women; age 67.0 ± 12.3 years) who underwent CT-guided percutaneous drainage at the university hospital or other affiliated medical institutions between March and December 2021. The inclusion criteria were as follows: (i) clinical manifestations of acute abdomen, including abdominal pain, signs of peritoneal irritation, abdominal distention, and clinical failure of conservative treatment with antibiotics and bowel rest, and (ii) CT imaging showing abscess formation in an area amenable to CT-guided drainage. The decision to perform CT-guided drainage was based on hemodynamic stability and coagulability (platelet count ≥50,000/μL and prothrombin time and international normalized ratio ≤1.5) [6] and was made in consultation with a gastroenterological surgeon, attending physician, and interventional radiologist.

Procedure

All procedures were performed by a board-certified interventional radiologist or a radiologist with experience in CT-guided procedures under the supervision of a board-certified interventional radiologist. The procedure was performed using the modified trocar technique with a *Drainaway* drainage kit and one of the following CT devices with CT fluoroscopy guidance: 320-row area detector CT (Aquilion ONE; Canon Medical Systems, Yokohama, Japan), 80-row area detector CT (Aquilion Prime SP; Canon Medical Sys-

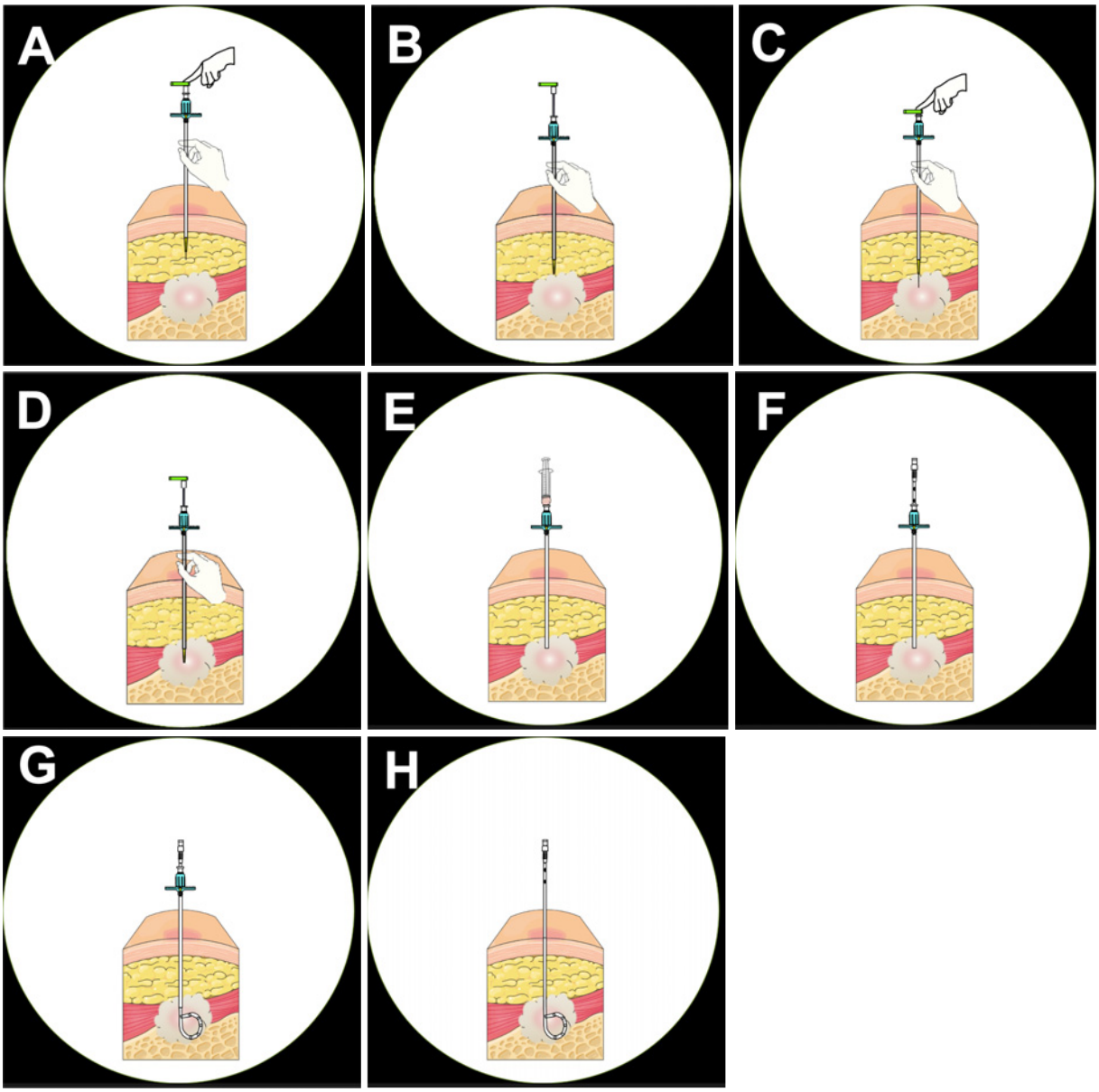

Figure 2. Abscess drainage using a modified trocar technique.
A: Carefully observing the CT image, the internal puncture needle is advanced to a safe position. The deepest possible advancement of the needle tip is 1.5 cm.
B: The peel-away sheath with the dilator is followed coaxially with the tip of the inner needle. If necessary, only the peel-away sheath with the dilator can be bluntly advanced without advancing the needle.
C, D: The "A followed by B" sequence is repeated several times over a short distance to allow the puncture needle and sheath with a dilator to reach the abscess cavity.
E: After the dilator and needle are removed, a suction connector is connected to the sheath to confirm aspiration of the abscess.
F: A pigtail catheter with the tip extended by a straightener is inserted into the sheath.
G: The catheter is inserted into the abscess cavity according to the manufacturer's instructions.
H: The sheath is detached and removed.
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tems, Yokohama, Japan), 64-row area detector CT (Aquilion CXL/Aquilion 64; Canon Medical Systems, Yokohama, Japan), or 256-row area detector CT (GE Healthcare, Milwaukee, WI, USA) or Brilliance iCT 256 (Philips Healthcare, Cleveland, OH, USA).

A radiopaque marker was placed on the body surface, and a CT scan was performed to determine the puncture site. After disinfecting the puncture site, local anesthesia with 1% xylocaine or lidocaine was administered to the skin, subcutaneous tissue, peritoneum or pleura, and hepatic capsule around the drain placement site using a 22-gauge needle. After incising the skin, a *Drainaway* drainage kit was used

Table 1. Patient Characteristics, Procedures, and Outcomes.

Characteristics	
Number of patients	27
Number of procedures	28
Age (mean ± SD)	67.0 ± 12.3
Sex	
Male	18 (67%)
Female	9 (33%)
Site	
Intraperitoneal	19 (70%)
Retroperitoneal	5 (19%)
Pleural	2 (7%)
Subcutaneous	1 (4%)
Abscess size (cm, mean ± SD)	7.1 ± 3.4
Cause	
Primary	12 (43%)
Postoperative	16 (57%)
Number of times exposed to CT fluoroscopy	34.2 ± 21.0
Procedure time (min, mean ± SD)	35.8 ± 11.4
CT scanner	
Canon Aquilion ONE	9 (33%)
Canon Aquilion Prime SP	7 (26%)
Canon Aquilion 64	4 (15%)
Canon Aquilion CXL	2 (7%)
GE Revolution 256	3 (11%)
Philips Brilliance iCT 256	2 (7%)
Drainage duration (days, mean ± SD)	17 ± 15.4
Technical success	27 (96.4%)
Clinical success	
Primary success	21 (77.8%)
Secondary success	26 (96.4%)
Complications	1 (3.7%)

Note: Data are shown in numbers of patients with percentages in parentheses.
SD, standard deviation

to reach the abscess under CT guidance. Specifically, the procedure of slightly advancing the internal puncture needle (20-gauge, 21.5 cm), followed by the peel-away sheath with a dilator (8-Fr, 20 cm) coaxially with the tip of the puncture needle under CT was considered one movement (**Fig. 2A, B**). This process was repeated several times to reach the abscess cavity little by little with the internal puncture needle and external sheath with a dilator (**Fig. 2C, D**). The dilator and needle were removed, ensuring that the sheath did not deviate from the abscess cavity, and a suction connector was connected to the sheath to confirm that the aspirated contents were abscess (**Fig. 2E**). After confirming the tip position of the sheath with CT, a pigtail catheter, tipped with a straightener, was inserted into the sheath (**Fig. 2F**). The catheter was slowly inserted into the abscess cavity according to the procedure manual (**Fig. 2G**), and after confirming its appropriate placement in the intended position using CT, the sheath was detached and removed (**Fig. 2H**). The catheter was secured using a fixation plate on the skin, and the procedure was completed. Whether additional treatment was required after drainage depended on the patient and was determined by the interventional radiologist and attending physician with consideration of the clinical conditions and underlying cause of the abscess.

Data collection and analysis

All patient clinical data and images, including age, sex, date of procedure, drainage site, size and cause of the abscess, number of CT fluoroscopy procedures, procedure time, CT equipment information, and duration to catheter removal, and clinical course, were obtained from electronic medical records. The procedure time was estimated from the time of CT scouting at the time of the puncture until the CT scan was performed to confirm the catheter placement. Technical success was defined as CT confirmation that the catheter was placed in the abscess cavity and the abscess was subsequently drained. Primary clinical success was defined as improvement in clinical symptoms, signs, and inflammatory markers to discharge-eligible levels. Clinical success with the *Drainaway* drainage kit alone was defined as primary clinical success, and clinical success with increased drain size or additional drainage was defined as secondary clinical success. Complications associated with the procedure were graded on the basis of the Common Terminology Criteria for Adverse Events (CTCAE) version 5.0 (v 5.0). Continuous variables are presented as mean ± standard deviation.

Results

Patient characteristics, procedures, and outcomes are shown in **Table 1**.

The puncture sites were intraperitoneal, retroperitoneal, and thoracic cavities in 19, 5, and 2 cases, respectively, and subcutaneous tissue in 1 case. The mean abscess size was 7.1 ± 3.4 cm. The mean procedural time was 35.8 ± 11.4 min. Postoperative and primary abscesses were found in 16 and 12 cases, respectively. Technical success was achieved in 27 of the 28 procedures (96.4%). In the technically unsuccessful case, the sheath of the *Drainaway* did not penetrate the sacrospinous ligament. Therefore, instead of using *Drainaway*, the abscess was punctured using an 18-gauge needle, and an 8-Fr catheter was placed using the Seldinger technique. The primary clinical success rate was 77.8% (21 of 27 patients), with a drainage period of 17.0 ± 15.4 days. The drainage period was 15.4 ± 16.5, 21.0 ± 10.3, and 23.0 ± 21.2 days for intraperitoneal (19 cases), retroperitoneal (5 cases), and thoracic (2 cases) abscess sites, respectively. All drainage procedures were performed using gravity drainage, and no special devices or methods, such as continuous suction drainage, were used. Six patients required an additional drain or drain size increase with an average drainage period of 11.2 ± 13.5 days. Five patients ultimately achieved secondary success (26 of 27 patients, 96.4%); however, one patient died from causes other than the abscess. No recurrent abscesses were observed after drainage catheter removal. One patient had a catheter deviate from the abscess cavity after 2 days, and a new drain was inserted the next

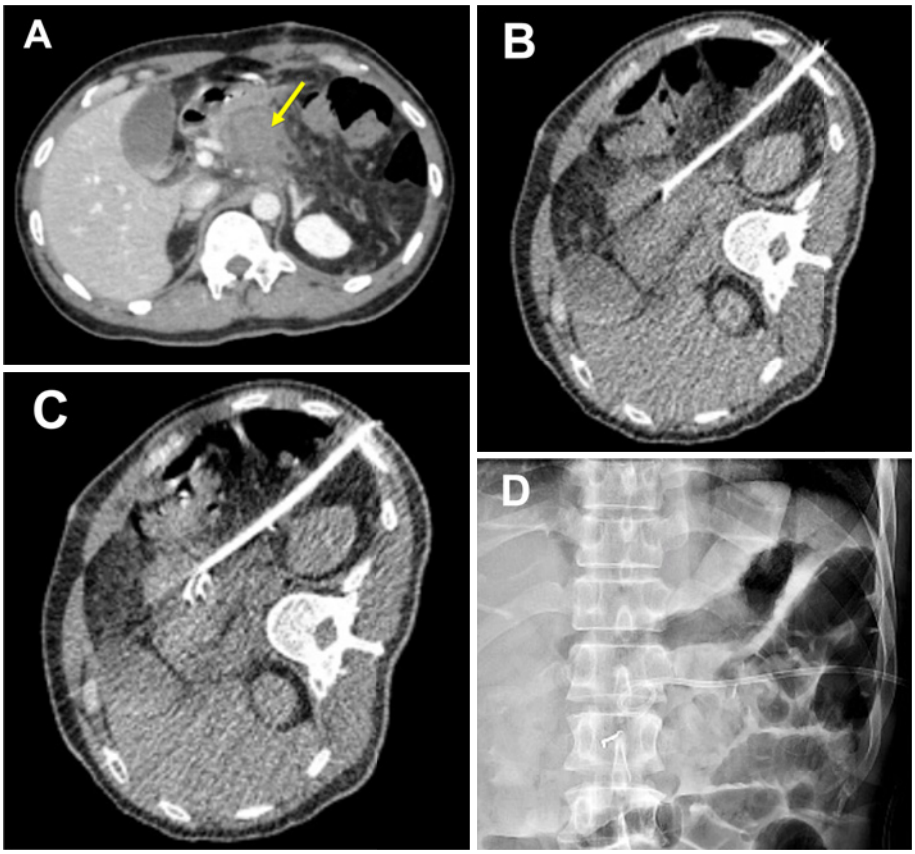

Figure 3. A 50-year-old man with pancreatic fistula after pancreatic tail cancer surgery. Postoperative pancreatic fistula (A, arrow) was confirmed using contrast-enhanced abdominal CT. The patient was placed in the right lateral decubitus position, and a puncture was made on the left side of his abdomen. The puncture needle was slightly advanced, and the dilator and sheath were followed coaxially. This process was repeated several times over a short distance to reach the abscess cavity (B). After CT confirmed that the tip of the sheath was in the abscess cavity, the pigtail catheter was slowly inserted into the cavity, and its placement in the intended position was confirmed using CT (C). Finally, an abdominal radiograph (D) confirmed that the catheter was not kinked.

day. One patient had a complication and required additional treatment for cholestatic pleurisy due to transthoracic puncture (CTCAE v5.0, grade 3; severe or medically significant but not immediately life-threatening; hospitalization or prolongation of hospitalization indicated). A representative case is shown in **Fig. 3**.

Discussion

In this study, we investigated the feasibility of CT-guided drainage using *Drainaway* based on a modified trocar technique for symptomatic patients with abscesses refractory to conservative treatment. Our results showed that using the *Drainaway* helped in the placement of an 8-Fr drain in various abscess regions using CT alone. Procedural success was achieved in 96.4% of the cases; procedural success was not achieved in one patient in whom a rigid ligament was present in the puncture path. Clinical success was achieved using *Drainaway* alone in 77.8% of the patients; additional drainage or increased drain size was required in 22.2% of the patients. Our study also showed that the *Drainaway* medical device can be used by any physician trained in interventional radiology, as our study was designed for seven centers where CT-guided drainage is available.

Tyng et al. [7] reported the usefulness of the modified trocar technique for CT-guided abscess drainage. They used a conventional trocar device to insert the tip of the device into the abdominal cavity under CT guidance, removed the internal stylet needle to blunt and increase the flexibility of the catheter tip, and slowly and cautiously advanced a drainage catheter with a metal-reinforced cannula toward the abscess. The basic idea of the *Drainaway* is the same as the concept of the method used by Tyng et al. [7]. However, the *Drainaway* is a more sophisticated system, with an improved structure and method compared with that used in the traditional trocar method. In the conventional method, the thin inner needle, thick hard metal inner tube, and outer drainage catheter connection are simultaneously advanced in a locked position, which can damage the blood vessels and intestinal tract around the abscess. The *Drainaway* is intentionally designed with a loose fit between the needle and sheath with a dilator to enable the advancement of the thin

puncture needle and subsequently the sheath with a dilator, allowing for a safer puncture. Additionally, by intentionally advancing only the sheath with a dilator bluntly without advancing the needle, the dilator sheath can be advanced in the desired direction without damaging the surrounding tissue with the sharp needle. The length and position of the catheter and the number of side holes can be freely adjusted by inserting the catheter after the sheath is inserted into the abscess. However, drainage of pelvic abscesses may involve puncturing hard ligaments, such as the sacrospinous ligament [8, 9]. In such cases, CT-guided drainage using the Seldinger method with a metal needle and a stronger puncture force might be more effective.

According to previous studies, clinical failure occurs in 5%-10% of abdominal and thoracic puncture drainage procedures [1]. The Society of Interventional Radiology recommends technical and clinical success rates of 95% and 85%, respectively [1]. We believe that the results of this study generally met these criteria. Clinical success rates vary depending on the nature of the drained contents, cause of the abscess, and severity of the underlying disease. Although simple fluids can be drained adequately using an 8-Fr catheter, it is estimated that viscous or pyogenic fluid drainage has a good chance of clinical success with a large catheter that is not likely to clog [10]. In the future, increasing the variation in the catheter size may further improve the clinical success rate of *Drainaway*. In this study, a CTCAE grade 3 complication (cholestatic pleurisy) occurred in one patient who underwent percutaneous drainage of a biliary fistula. This complication could have been prevented by cautiously taking a puncture route that avoided the transthoracic route during the procedure.

This study had some limitations. As this was a retrospective feasibility study with a short period of inclusion, the sample size was limited, and further subgroup analysis was not possible. Similarly, this observational study lacked a control group, and further studies are required to validate the efficacy and safety of the method using the *Drainaway* kit.

In conclusion, the modified trocar technique using the *Drainaway* drainage kit allows safe and effective percutaneous drainage using only CT guidance without X-ray fluoroscopy.

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Conflict of Interest: None

Author Contribution: Seishi Nakatsuka conceptualized and designed the study; Koji Togawa and Jitsuro Tsukada reviewed the literature; Yosuke Yamamoto, Togo Kogo, Hiroki Yoshikawa, Manabu Misu, Masashi Tamura, Jitsuro Tsukada, Nobutake Ito, Shigeyoshi Soga, Masanori Inoue, Hideki Yashiro, Tadayoshi Kurata, Masahiro Okada, and Seishi Nakatsuka collected the clinical data; Koji Togawa and Jitsuro Tsukada analyzed the data. Koji Togawa, Jitsuro Tsukada, and Nobutake Ito wrote the manuscript; Seishi Nakatsuka edited the manuscript; Masahiro Jinzaki ensured the integrity of the entire study.

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