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Ultrasonic/CT image fusion guidance facilitating percutaneous catheter drainage in treatment of acute pancreatitis complicated with infected walled-off necrosis

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ABSTRACT

Background: As the firs-line treatment for acute pancreatitis (AP) related infectious walled-off necrosis (WON), percutaneous catheter drainage (PCD) are usually accomplished under CT or US guidance, either of which has certain disadvantages. It is necessary to verify the clinical effects of using US and CT images fusion as guidance of PCD.

Methods: The total 94 consecutive AP patients with infected WON from January of 2013 to January of 2017 were included. Among these patients with infected WON, 48 received PCD under simple US guidance (US-PCD) and 46 under US/CT images fusion guidance (US/CT-PCD). The clinical data consisting of puncture data, drainage effectiveness indicators, intervention complications were collected.

Results: The demographic characteristics and disease related characteristics of two groups were comparable. After 48 h of PCD treatment, the US/CT-PCD group achieved a significantly higher imaging effective rate, and significantly lower inflammatory response indexes and severity score, than the US-PCD group ($P < 0.05$). The US/CT-PCD group required fewer puncture times and drainage tubes and lower rate of advanced treatment, showing higher operational success rate than the US-PCD group ($P < 0.05$). Moreover, the US/CT-PCD group exhibited significantly fewer puncture related complications, lower hospital stay, intubation time, and hospitalization expenses than the US-PCD group ($P < 0.05$).

Conclusion: PCD treatment under the US/CT images fusion guidance is a reliable intervention with definite clinical effects for AP complicated with infected WON.

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1. Introduction

Severe acute pancreatitis (SAP) is difficult to cure [1]. Deaths caused by early multi-organ functional disturbances have decreased significantly with the development of intensive care unit technology. However, the late complications of sepsis caused by pancreatic necrosis infection and relevant organ failure have become the main causes of deaths [2]. The cause of death in AP patients is a consequence of complications in 80% of cases [2–5]. In 2012, the international consensus on the revised acute pancreatitis (AP) classification and definition was released, which further classifies the local complications of AP and better guides the management of various fluid collections. Among these fluid collections, walled-off necrosis (WON) is often accompanied with systematic inflammatory reaction syndromes and is difficult to treat. The

Abbreviations: AP, acute pancreatitis; CT, computed tomography; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasound; FNA, fine needle aspiration; MSAP, moderately severe acute pancreatitis; IDUS, intraductal ultrasonography; PCD, Percutaneous catheter drainage; SAP, severe acute pancreatitis; US, ultrasound; VARD, video-assisted retroperitoneal debridement; WON, walled-off necrosis.

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combination of minimally invasive video-assisted retroperitoneal debridement (VARD) and percutaneous catheter drainage (PCD) is widely accepted as an effective therapy for WON.

Previously reported PCD interventions were mainly accomplished under CT or US guidance. Both CT and US guidance have certain advantages. On the one hand, CT guidance is superior to US guidance because WON is at the retroperitoneal position and CT can display WON boundaries, quantities, and organs on the puncture pathway without any disturbance from the gases in the gastrointestinal tract [6,7]. On the other hand, US guidance is superior in PCD intervention because of its real-time, repeated puncture, radiation-free, and bedside operations [8,9]. In clinics, different institutions select the guidance approach based on practical situations and technological characteristics. As one of the earliest special US diagnosis and treatment centers in China, we first introduced the US/CT images fusion technology in PCD intervention. After matching the spatial position and coordinating the orientation between the CT and US orientation, the 2D ultrasonogram and plane scanning CT images can be simultaneously visualized on the US displayer. In real operations, this fusion technology helps in accurately visualizing WON's location, scope and quantity of focus, and neighboring relation with the surrounding important organs and blood vessels on the US displayer. This technology also offers optimum safety and effective puncture pathway and provides a basis for sufficient drainage and debridement with choledochoscope after tube expansion.

Although the validity of US/CT images fusion guidance for PCD has been preliminarily verified in our clinical center, its practical application is still limited and should be further expanded. The advantages of US/CT images fusion guidance over single US image guidance remains unexplored. This retrospective study aims to discuss the safety and effectiveness of PCD intervention under US/CT images fusion guidance for the treatment of infected WON.

2. Patients and methods

2.1. Patients

The participants included 329 patients with moderately severe acute pancreatitis (MSAP) and severe acute pancreatitis (SAP) that were admitted our hospital from January 2013 to January 2017. Among these patients, 94 had WON accompanied with infections four weeks after the onset and subsequently underwent PCD. Diagnosis of MSAP, SAP, and WON are based on the revised standards of Atlanta [10,11]. Among the 94 patients, first 48 consecutive patients received US-PCD, and the later rest were treated by US/CT-PCD (Figure S-1). Informed consent for the interventional procedures was obtained from each patient. Data were collected and analyzed retrospectively. This study was approved by the Ethical Committee of the Chengdu Military General Hospital.

2.2. Inclusion and exclusion standards

2.2.1. Inclusion standards

(1) Adults (>18 years old) who suffered the first episode of MSAP or SAP and underwent PCD. (2) WON (diagnosed according to abdomen CT images) accompanied with infection (diagnosis basis: excessive leukocyte level in blood routine examination, fever, bubbles in peripancreatic necrosis tissues in abdomen CT images, and positive bacterial culture in drainage liquid from fine needle aspiration (FNA) or the first PCD drainage tube) that appeared 4 weeks after the onset of AP.

2.2.2. Exclusion standards

(1) AP subsequent to a second disease, endoscopic retrograde cholangiopancreatography, and suspected malignancy of the pancreas or biliary tree. (2) Patients with a medical history of immune deficiency, previous abdominal operation (exploratory laparotomy), or intraoperative diagnosis of AP.

2.3. Treatment

In this study, we applied a novel step-up approach, which has been reported previously, consisting of four successively steps: conservative treatment, abdominal paracentesis drainage (APD), PCD and necrosectomy [12].

2.3.1. Therapeutic equipment and materials

GE LOGIQ E9 diasonograph with C1-5 probe (GE, USA), pig tail-type puncture needles (12F) (Bangtuo, Taiwan), COOK expanding tube (COOK, USA), and fiber choledochoscope (Olympus, Japan) were used (Fig. 2).

2.3.2. PCD intervention

According to our previous clinical studies, the 12F drainage tube shows the highest safety and effectiveness in PCD intervention. In this study, 12F pig tail-type drainage tubes were used in both groups for the first PCD intervention [12].

The procedures for US/CT-PCD are as follow: (1) Image acquisition and import: the CT image for fusion (digital Imaging and Communications in Medicine (DICOM) format) was acquired within one week and imported into the US instrument (Fig. 2). (2) Image matching and fusion: image localization was the core. We chose the popular in-vivo expression method based on internal characteristics. In this method, the probe acoustic beamed perpendicular to the abdomen of patients (lock plane), labeled the inherent dissection signs on the CT image (e.g., intrahepatic portal vein, hepatic vein bifurcation, celiac trunk, and origin of the renal artery), identified and marked all lock points on the US image, and maintained the same dissection points with similar spatial positions on the matched images. CT images can offer a real-time display of the corresponding plane according to the scan using the US probe (Fig. 1A and B). (3) Selection and implementation of puncture pathways: WON position, scope, and surrounding important organs were first recognized on the CT image. The drainage tube was placed at the lowest position of WON and safe puncture pathway. When the adjacent WONs were not connected, the two tubes were inserted to ensure smooth drainage in each WON. After performing the US/CT images fusion, the safe puncture pathway on the CT image was displayed on the US image (Fig. 1C and D). Subsequently, PCD intervention was implemented along this pathway under US guidance (Fig. 1E and F).

The patients in US-PCD group underwent conventional US scanning to reveal the WON focus. The puncture pathway for PCD drainage was chosen based on the 2D US image.

2.3.3. Tube expansion and debridement with choledochoscope

After 7 days of PCD intervention, if the drainage of necrotic tissues was insufficient and US examination indicated large residual WON, the patients received another CT examination and tube expansion treatment according to the CT image. Moreover, debridement with choledochoscope had to be implemented when the expansion treatment failed to improve the drainage effect significantly. The COOK expanding tube expanded the sinus tract of the 12F drainage tube to 16F–24F. Necrotic tissues were removed by a biopsy clamp through the lithotomy net under the direct view of choledochoscope, and the vomica was washed.

2.3.4. Indicators for removal of drainage tube

The drainage tube was removed when all the following

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