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Original

Investigating of the Usefulness of Multidetector-row Computed Tomography for Diagnosing Abdominal Visceral Pseudoaneurysms

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Abstract : Abdominal visceral pseudoaneurysms are rare, but rapid diagnosis is clinically important because of the associated conditions that are often fatal. Multidetector-row computed tomography (MDCT) is important in the diagnosis and treatment of many human conditions. This study thus sought to investigate the usefulness of MDCT for diagnosing abdominal visceral pseudoaneurysms. We retrospectively assessed the MDCT diagnosis of pseudoaneurysms and identification of the responsible vessels or cases diagnosed with an abdominal visceral pseudoaneurysm via angiography. The study comprised 35 patients who underwent MDCT preoperatively and in whom angiography detected an abdominal visceral pseudoaneurysm over a 7-year period. Using the angiography findings as the gold standard, we investigated whether a pseudoaneurysm and the responsible vessel could be diagnosed using preoperatively imaged MDCT findings. For angiography and MDCT, diagnosis was reached on the basis of two radiologists' agreement. Of 35 patients (28 males and 7 females), the median subject age was 67 years (range : 22-84 years). We found that MDCT could preoperatively detect abnormal findings such as hematomas in all patients. MDCT detected the presence of a pseudoaneurysm in 88.6% (31/35) of patients and identified the responsible vessel in 71% (25/35) of patients. In 6 patients, MDCT findings could successfully reveal both the pseudoaneurysm and the extravasation. MDCT was effective for diagnosing abdominal visceral pseudoaneurysms and it could be useful for determining treatment strategies and aiding treatment techniques in such patients.

Key words : abdominal visceral pseudoaneurysm, MDCT

Introduction

Abdominal visceral pseudoaneurysms are a form of arterial injury and are usually diagnosed by means of diagnostic imaging. The final diagnosis is performed via an angiography, and percutaneous vascular embolization, as interventional radiology is often selected for treatment. This is an extremely serious condition with a high fatality rate, and it is important to perform a rapid diagnosis and treatment^{1, 2)}. Since the introduction of multidetector-row computed tomography (MDCT), testing methods and indications for this technology have expanded to

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include the diagnosis of various diseases due to its high temporal and spatial resolution. It has also become an essential method of testing for diagnosing emergency abdominal diseases. MDCT plays an important role in the diagnosis of hemorrhage and bleeding source in abdominal emergency medicine^{3, 4)}. There have been some studies reporting that MDCT is useful for diagnosing gastrointestinal bleeding⁵⁾ and in identifying vessel damage and the bleeding source following a delivery⁶⁾. There have been a significant number of case reports regarding the usefulness of MDCT for diagnosing pseudoaneurysms of abdominal organs^{7, 8)}. However, very few reports have summarized the diagnostic usefulness of MDCT in cases of abdominal visceral pseudoaneurysms. Even cases of potentially fatal condition of visceral pseudoaneurysms may progress favorably if percutaneous vascular embolization is quickly and successfully performed⁹⁻¹²⁾. Therefore, it is important to clarify the diagnostic usefulness of MDCT due to the importance of early diagnosis and treatment. The purpose of this study was to assess the usefulness of MDCT for the diagnosis of the abdominal visceral pseudoaneurysms. Here, we retrospectively investigated the MDCT diagnosis of pseudoaneurysms and identification of the responsible vessel for cases diagnosed with an abdominal visceral pseudoaneurysm via angiography.

Materials and methods

Subjects comprised of 35 patients who underwent MDCT preoperatively and in whom angiography detected an abdominal visceral pseudoaneurysm over the 7-year period from January 2008 to October 2014 at Showa University Hospital. Using angiography findings as the gold standard, we investigated whether preoperative MDCT findings could detect a pseudoaneurysm and identify the responsible vessel. The imaging was carried out using a 64-row MDCT (SOMATOM Sensation 64; SIEMENS, Germany) for 31 patients and a 128-row MDCT (Definition AS+; SIEMENS, Germany) for the remaining 4 patients. For imaging, patients weighing 75 kg or more received 100 ml of a non-ionic contrast medium used at either 350 or 370 mg/ml. Patients weighing 45–74 kg received 100 ml of contrast medium at 300 mg/ml, and patients weighing less than 45 kg received 75 ml of contrast medium at 300 mg/ml. The only exception to this protocol was one patient who weighed 43 kg and received 86 ml (2 ml per 1 kg body weight) of 300 mg/ml contrast medium. While 4 patients underwent imaging 80-s after receiving the contrast medium, 31 patients underwent a dynamic study, receiving non-contrast imaging at 30-s and 80-s time points. The imaging protocol was determined for each patient by an attending physician or a radiologist on the basis of clinical symptoms. Evaluation was performed using images reconstructed from 5-mm slices. In addition, the data of 17 patients obtained using thin 1.5-mm slices were compared with those using the 5-mm slice reconstructions. Angiography was performed in all patients using the Axion Artis (SIEMENS, Germany). Criteria for diagnosing a pseudoaneurysm were local blood vessel dilation on both MDCT and angiography (at least 1.5 times normal diameter) or the presence of an aneurysm structure contrasted to the same extent as adjacent arteries. For angiography and MDCT diagnosis, the diagnosis was reached on the basis of the concordance of at least two radiologists. The ethics review board of Showa University School of Medicine approved the study protocol.

Table 1. MDCT findings of diagnosis and responsible vessels in all cases

Responsible vessel	A	B	C	Total
Gastroduodenal artery	6 patients	2 patients	1 patient	9 patients
Right hepatic artery	6 patients		1 patient	7 patients
Replaced right hepatic artery	1 patient			1 patient
Middle hepatic artery	1 patient			1 patient
Left hepatic artery	1 patient			1 patient
Splenic artery	4 patients			4 patients
Uterine artery	2 patients	1 patient		3 patients
Right colic artery		2 patients		2 patients
Dorsal pancreatic artery	1 patient		1 patient	2 patients
Left inferior phrenic artery	1 patient			1 patient
Left gastric artery	1 patient			1 patient
Right gastroepiploic artery		1 patient		1 patient
Inferior pancreaticoduodenal artery	1 patient			1 patient
Right inferior suprarenal artery			1 patient	1 patient
Total	25 patients	6 patients	4 patients	35 patients

A : Cases in which both the pseudoaneurysm and responsible vessel could be diagnosed.

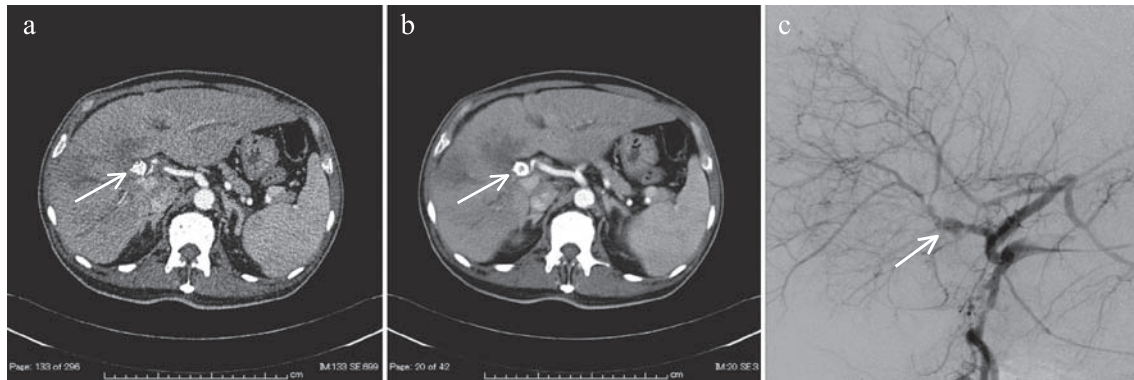
B : Cases in which the pseudoaneurysm could be diagnosed, but the responsible artery could not be diagnosed.

C : Cases in which the pseudoaneurysm could not be detected.

Results

The original MDCT test objectives for the patients in this study were as follows: bleeding source testing (27 patients), detailed abdominal pain testing (3 patients), follow-up observation of primary disease (2 patients), detailed testing of cause of decreased blood pressure (1 patient), detailed testing for vomituration (1 patient), and evaluation of multiple injuries (1 patient). The most common primary disease was malignancy-related lesions (18 patients), including 1 patient with postoperative esophageal cancer, 4 patients with gastric cancer (including 1 postoperative patient), 9 patients with bile duct cancer (including 6 postoperative patients), 3 patients with postoperative duodenal cancer, and 1 patient with hepatocellular carcinoma. Other causative diseases included one patient with post-acute pancreatitis, five patients with post-chronic pancreatitis (including three postoperative patients and one post-acute exacerbation patient), three patients with an external injury, three patients with duodenal ulcer, one patient with post-cholecystectomy infectious complications, one patient with post cholangitis, three patients with atonic hemorrhage (including one post-total hysterectomy patient), one patient with post-acute cholecystitis, and one patient with idiopathy.

Our retrospective examination of the pre-angiography MDCT imaging (Table 1) revealed the presence of a pseudoaneurysm in 88.6% (31/35) of patients and visualization of the responsible vessel in 71% (25/35) of patients. In six patients, the rendered MDCT images revealed not only the pseudoaneurysm, but also the extravasation. In all patients, findings suggestive of a hemorrhage, such as a hematoma, were confirmed and the location of the bleeding source could



1.5-mm resolution imaging

5-mm resolution imaging

Fig. 1. 63-year-old male. A metallic stent had been placed in the bile duct due to bile duct cancer. Due to the progression of anemia, contrast-enhanced CT was performed to determine the source of bleeding. No clear abnormalities were noted using 5-mm slice data. However, we were able to identify a pseudoaneurysm (arrow) in the right hepatic artery within the metallic stent using thin 1.5-mm slice data.

be estimated.

MDCT was more useful in 17 patients with the 1.5-mm slice reconstruction data compared to in the 5 patients with 5-mm slice data, as follows: 3 patients could be diagnosed with a pseudoaneurysm on the basis of 1.5-mm slice data only, 1 patient in whom the responsible vessel was identified from 1.5-mm slice data only, and 1 patient for whom the pseudoaneurysm could not be identified from 5-mm slice data but the pseudoaneurysm and responsible vessel could be identified from the comparable 1.5-mm slice data.

The hepatic artery was most commonly the responsible vessel, being identified in 10 patients (right hepatic artery: 7 patients, left hepatic artery: 1 patient, middle hepatic artery: 1 patient, and replaced right hepatic artery: 1 patient), making it the most common. This was followed by the gastroduodenal artery (9 patients), splenic artery (4 patients), uterine artery (3 patients), right colic artery (2 patients), dorsal pancreatic artery (2 patients), left inferior phrenic artery (1 patient), left gastric artery (1 patient), right gastroepiploic artery (1 patient), inferior pancreaticoduodenal artery (1 patient), and right inferior suprarenal artery (1 patient).

MDCT performed preoperatively failed to detect a pseudoaneurysm in 4 patients, including one patient with post-bile duct cancer and hematemesis in whom a metal stent was inserted and the responsible vessel was the right hepatic artery (Fig. 1), 1 patient with multiple injuries due to a traffic accident (Fig. 2), 1 patient with massive gastric cancer in which the cause of bleeding was invasion of the gastroduodenal artery, and 1 patient with duodenal ulcer bleeding for which the responsible vessel was the dorsal pancreatic artery.

Discussion

In MDCT, multiple X-ray detectors are placed rostrocaudally to enable multiple image data collection during a single rotation of the X-ray tube, thus achieving dramatically improved

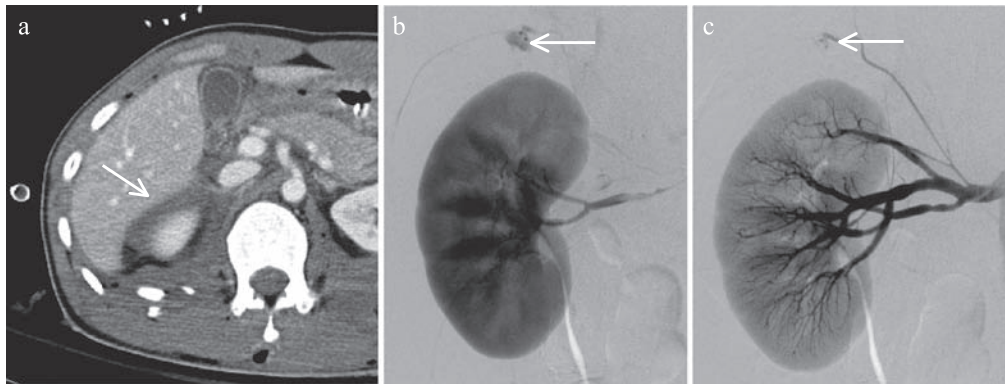


Fig. 2. 22-year-old male. The patient had multiple injuries due to a traffic accident. Physical examination suggested a left hemopneumothorax. Contrast-enhanced CT, performed for general evaluation, detected the hemopneumothorax and multiple intercostal artery injuries accompanying multiple rib fractures. A small hematoma was also noted near the superior pole of the right kidney. Angiography was performed with the aim of intercostal artery embolization. Because a hematoma was present, additional digital subtraction angiography imaging was performed from the right renal artery. This revealed a pseudoaneurysm (arrow) in the right inferior suprarenal artery. As this was a retrospective investigation, contrast-enhanced CT was unable to identify the pseudoaneurysm or extravasation.

spatial and temporal resolution compared with single-detector CT. In particular, the enhanced rostrocaudal spatial resolution of 0.5–1 mm can be utilized to create three-dimensional images using volume rendering (VR) and highly precise multiplanar reformation (MPR) images (Fig. 3)¹³. This power was exemplified recently *in vitro* when MDCT showed the highest sensitivity for detecting active hemorrhagic lesions compared with the gold standard of digital subtraction angiography¹⁴.

In our study, MDCT could detect abnormal findings such as hematomas preoperatively in all patients, while pseudoaneurysms were localized in 88.6% (31/35) of patients and the responsible vessel was identified in 71% (25/35) of patients. These findings suggest that MDCT is effective not only for diagnosing abdominal visceral pseudoaneurysms, but also for determining treatment strategy and aiding treatment techniques.

Our comparison of 1.5-mm vs. 5-mm slice data for image reconstruction further indicated the superior diagnostic ability of MDCT in that pseudoaneurysms and the causative vessel were detected in 29% (5/17) of patients. Indeed, based on these findings, we would recommend that image construction using the thin slice data be used routinely.

The four patients studied herein for whom the pseudoaneurysm could not be detected were investigated in further detail. The first patient exhibited a pseudoaneurysm within a metallic stent, but the structure could not be image-rendered on MDCT, even using 1.5-mm slice data, due to artifacts. The second patient had multiple injuries with the associated presence of many artifacts, including the tube and a pneumoderma, in addition to general instability such as decreased blood pressure. A hematoma was noted in the kidney area of this patient, but the surrounding vessel structure was not successfully rendered. In the third patient, a

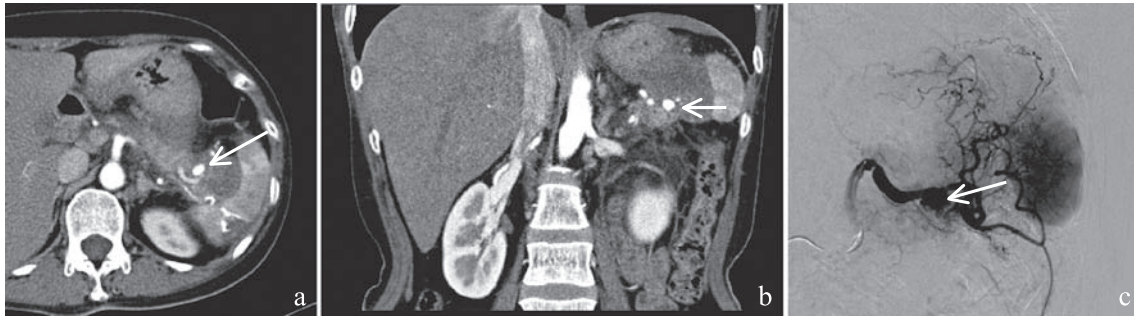


Fig. 3. 42-year-old female. The patient was being treated for chronic pancreatitis. She underwent contrast-enhanced CT for detailed examination after suffering sudden flank pain, back pain, and vomiting of blood. A pseudocyst extending from the pancreatic tail to the splenic hilum region was observed. Inside this, we noted a pseudoaneurysm (arrow) protruding from the splenic artery. This was also visible on MIP images and was similar to the angiography findings.

terminal gastric cancer case, MDCT suggested gastrointestinal bleeding and massive intratumoral hemorrhage, but the relevant images could not be rendered. The fourth patient had duodenal ulcer bleeding with hemorrhagic shock. As for the first and second patients, artifacts caused by medical devices such as tubes and metallic stents near the lesion were detected by MDCT in this patient, and it was difficult to detect the pseudoaneurysm. The second, third, and fourth patients exhibited hemorrhagic shock, and it is possible that the associated decreased blood pressure and vasospasms led to a temporary state of hemostasis, resulting in the pseudoaneurysms not being rendered when MDCT was performed. Indeed, the fourth patient showed no pseudoaneurysms during the first session of angiography and additional vascular embolization was required. Based on the findings for these four patients, we expect that the bleeding source and possibility of endovascular treatment could be predicted during angiography for cases with a medical device inserted or in a poor general state, even if the bleeding source cannot be determined from MDCT findings.

Vascular injury can be recognized by typical changes over time¹⁵⁾, in particular, contrast medium extravasation, pseudoaneurysm, arteriovenous (AV) fistula, and vessel truncation^{16, 17)}. These findings support our suggestion that for severe pathologies, such as vascular injury (Fig. 4), that might exhibit a diverse range of imaging findings, two-dimensional evaluation by angiography alone could lower the overall diagnostic capability and limit treatment options. In addition, performing MDCT to estimate the site of vascular injury could greatly impact individual treatment strategies. Determining whether it is technically possible to perform vascular embolization or whether surgical treatment is required is an important element in deciding treatment policy together with general patient status and clinical findings¹⁸⁻²⁰⁾. Having a better preoperative understanding of the vascular anatomical features of a case could also enhance the success of vascular embolization or surgery; for example, in pursuing vascular embolization, MDCT could influence the choice of device such as a catheter, while for surgical treatment the MDCT findings could influence the choice of procedure¹⁹⁾. Thus, the degree of difficulty of surgical techniques could be determined preoperatively and complications likely to accompany

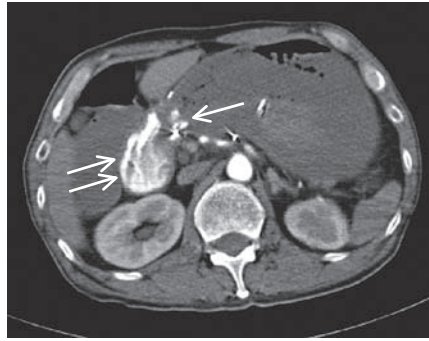


Fig. 4. 60-year-old male. The patient was being followed up for terminal rectal cancer. He had vomited blood and thus contrast-enhanced CT was performed due to suspected gastrointestinal hemorrhage. Contrast-enhanced CT indicated pseudoaneurysm of the gastroduodenal artery and extravasation expanding within the duodenal lumen. Angiography also revealed the pseudoaneurysm (one arrow) and extravasation (two arrows).

treatment could also be estimated. Certainly, there are disadvantages associated with increased radiation exposure and increased usage of contrast medium; however, we believe that it is extremely important to conduct general evaluation and to identify the source of bleeding and responsible vessel preoperatively for serious diseases such as those discussed here.

Limitations of our study include its retrospective nature, meaning that the imaging protocol assessed was not uniform. However, as imaging was performed by either contrast-enhanced dynamic study or single-phase contrast-enhanced study, we believe that such a limitation introduced no significant problems with our evaluation. Further investigation regarding methods of contrast medium administration, dosage, and imaging protocols are required in the future.

In conclusion, MDCT is useful for diagnosing the presence of abdominal visceral pseudoaneurysms and evaluating the responsible vessel. Further improvement in diagnostic capability could be anticipated by evaluating MDCT using thin slice image data.

Conflict of interest disclosure

The authors have declared no conflict of interest.

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