Value of multi-detector computed tomography combined with serum tumor markers in diagnosis, preoperative, and prognostic evaluation of pancreatic cancer

Jianli Su1, Yunfeng Wang2, Hua Shao3, Xinting You4 and Shuying Li5*

Abstract

Background: Multi-detector computed tomography (MDCT) and serum tumor markers are commonly used in the diagnosis of pancreatic cancer (PC). In this article, we focused on the evaluation of the clinical value of MDCT combined with serum tumor markers CA199, CA242, and CEA in diagnosis, preoperative, and prognostic evaluation of PC.

Methods: Eighty-five PC patients (PC group) and 39 patients with pancreatitis (control group) admitted to our hospital were selected for our present research study. MDCT, CA199, CA242, and CEA examination were examined in all patients, and their value in diagnosis, preoperative, and prognostic evaluation of PC was retrospectively analyzed.

Results: There were 69 patients whose clinical staging results of MDCT were consistent with the postoperative pathological diagnosis. The coincidence rate was 70.00% in stage I, 62.96% in stage II, 72.72% in stage III, and 80.00% in stage IV, respectively, and the overall coincidence rate was 69.57%. The levels of CA199, CA242, and CEA in PC group were remarkably higher than those in control group and were sharply correlated with clinical stage, differentiation degree, and distant metastasis. The sensitivity, accuracy, and negative predictive value of MDCT combined with serum CA199, CA242 and CEA in the diagnosis of PC were significantly improved compared with those of each single test. In PC group, the 2-year event-free survival rate of the group with high CA199, CA242, and CEA expression was remarkably lower than that of the low expression group.

Conclusion: MDCT combined with CA199, CA242, and CEA notably improved the diagnostic efficiency of PC and had guiding significance for preoperative and prognostic evaluation of PC.

Keywords: Pancreatic cancer, Multi-detector computed tomography, CA199, CA242, CEA

Introduction

Pancreatic cancer (PC) is a ductal adenocarcinoma mostly originating from the glandular epithelium, which is a common malignant tumor of the digestive system. Pancreatic cancer is one of the malignant tumors with a high degree of malignancy and a seriously poor prognosis [1]. With the increase of work pressure, the fast pace of life and the change of diet structure, the incidence of PC has been on the rise worldwide [2]. The pancreas is located behind the peritoneum of human body and is hidden, with many blood vessels and other organs distributed nearby, so it is different to detect PC early. Moreover, there are no typical clinical symptoms in the early stage and the
diagnosis is often in the middle and late stages, leading to a poor prognosis [3]. It is reported that the 5-year survival rate of advanced PC is less than 5% [4]. Therefore, early diagnosis of PC, correct assessment of the disease before treatment and formulation of the best treatment are of great significance for improving the prognosis [5]. Imaging is an important means for the diagnosis of PC. Ultrasound is often used as the first choice for the diagnosis of PC, due to its low cost and non-invasive characteristics. However, due to the deep anatomical position of the pancreas and the influence of anterior intestinal gas, it is not effective in identifying small lesions, differentiating benign and malignant tumors and tumor invasion, and is not suitable for the early diagnosis of PC [6]. Multi-detector computed tomography (MDCT) is one of the most commonly used imaging techniques for the diagnosis of PC, which can provide an objective basis for the diagnosis and preoperative clinical staging evaluation [7]. Serum tumor markers are not only used in the early diagnosis, but also have certain value in prognostic evaluation as quantitative indicators in PC [8].

In this study, 85 patients with PC were retrospectively analyzed to investigate the clinical value of MDCT combined with serum markers, and to provide reference significance for the early diagnosis of PC.

Materials and methods
Clinical data
From January 2016 to December 2018, 85 patients with PC (PC group) and 39 patients with pancreatitis (control group) admitted to Qilu Hospital (Qingdao) were selected as the research objects. PC group: There were 46 cases of painless jaundice, 80 cases of upper abdominal discomfort, and 73 cases of weight loss. There were 56 males and 29 females. The age range was 35–69 years, with an average of 51.26 ± 8.94 years. Control group: there were 25 males and 14 females. The age ranged from 34 to 70 years, with an average of 52.10 ± 9.03 years. Inclusion criteria were as follows: (1) patients were confirmed by histopathology, (2) patients were newly diagnosed, and examined by MDCT and serum tumor markers CA199, CA242, and CEA, (3) patients were informed of the study and signed the consent form. Exclusion criteria were as follows: (1) with signs of organ failure such as heart, lung, liver and kidney, (2) without pathological diagnosis, (3) incomplete research data, (4) with other malignant tumors, (5) patients allergic to iohexol. There was no statistical difference in general data between the two groups (p > 0.05), with comparability. This study was approved by the ethics committee of our hospital (YYLUNLH20150230).

MDCT examination
Discovery CT 750 HD CT (GE, USA) was used for MDCT examination. The patients were forbidden to eat or drink for 8 hours prior to the examination, which must be performed on an empty stomach. Before examination, patients drank 600 mL of water to fill the duodenum. All positions from the lower kidneys to the top of the diaphragm were sequentially scanned, followed by enhanced scans. The scanning parameters were 2.5 mm of interval and layer thickness, rotation time of 0.5 s/rot, field of view of 348 × 348, collimation of 0.5mm, scanning current and voltage of 300 mA and 120 kV respectively. The contrast agent iohexol was injected into the cubital vein at 3~4 mL/s. Arterial phase, parenchymal phase and delayed phase scanning were performed 20~25, 35~40, and 60~70 s after contrast injection, respectively. The images were processed on a MDCT system. The radiographic review was carried out by two imaging physicians, including the size, morphology, edge, degree of enhancement, nerve infiltration, lymph node metastasis, and tumor stage.

MDCT of PC showed irregular spherical shape with unclear margin and maximum density difference from surrounding normal pancreatic parenchyma. MDCT scan images of PC are shown in Fig. 1. MDCT images of pancreatitis are shown in Fig. 2.

Preoperative clinical staging were as follows [9]: stage I: the diameter of the lesion was less than 2 cm, the lesion was confined to the pancreatic capsule without vascular involvement. Stage II: the tumor was 2–4 cm in diameter, and the capsule was infiltrated by cancer cells without vascular involvement. Stage III: the tumor diameter was over 4 cm, and lymph node metastasis was less than two stations, but with no distant metastasis. Stage IV: the tumor diameter was more than 4 cm, with lymph node metastasis at more than three stations and with distant metastasis.

Serum tumor markers
3.5 ml elbow venous blood was extracted from the two groups on an empty stomach from 6:00–8:00 a.m., and the serum was separated by centrifugation after standing for self-coagulation. CA199, CA242, and CEA were detected by Electro-Chemiluminescence Immunoassay (Roche Elecsys-2010, Switzerland).

Evaluation methodology
MDCT results of PC consistent with pathological diagnosis was defined as true positive, and inconsistent was defined as false negative. MDCT results of benign pancreatic lesions consistent with the pathological diagnosis was defined as true negative, and inconsistent was false
positive. Serum tumor marker less than or equal to the critical value was considered as negative, and greater than the critical value was judged as positive. Joint examination was judged as positive when one or more items were positive, and as negative when all items were negative.

**Follow-up**
After treatment, patients came to the hospital for re-examination every 2 months, including imaging (CT, magnetic resonance, ultrasound) and serum tumor markers, plus 18F-FDG PET/CT if necessary. Follow-up was discontinued when recurrence, metastasis, or death occurred. No recurrence, metastasis or death occurred during the follow-up period, and the end point of the follow-up period was 24 months.

**Statistical analysis**
SPSS19.0 statistical software was used for data analysis. Measurement data were expressed by mean ± standard deviation, and comparison between the two groups was performed by t test. The count data were expressed as rate (%), and χ² test was used for comparison between groups. The diagnostic value of MDCT, CA199, CA242, and CEA in PC was calculated by four-grid table method. Kaplan-Meier method and log-rank were used to test survival analysis. p < 0.05 was considered statistically significant.

**Results**
**Diagnostic analysis of PC and pancreatitis by MDCT**
After MDCT examination of 85 PC, 69 cases (true positive) were consistent with pathological diagnosis, and 16 cases (false negative) were misdiagnosed. In 39 cases of pancreatitis, the results of MSCT were consistent with pathological diagnosis in 34 cases (true negative), and 5 cases were misdiagnosed as PC (false positive). The pre-operative clinical staging of MDCT in 69 patients with PC was compared with postoperative pathological staging. The coincidence rate of stage I, II, III, and IV assessment was 70.00% (7/10), 62.96% (17/27), 72.72% (16/22), and 80.00 (8/10), respectively, and the overall coincidence rate was 69.57% (48/69) (Table 1).

**Comparison of serum CA199, CA242, and CEA expression levels between PC group and pancreatitis group**
The levels of CA199, CA242, and CEA in patients with PC were sharply higher than those in patients with pancreatitis (p < 0.01, Table 2).
Correlation analysis of CA199, CA242, CEA expression levels, and clinicopathological factors in PC

The expression levels of CA199, CA242, and CEA in PC group had no significant correlation with gender, age, and tumor site (p > 0.05), but were notably correlated with clinical stage, differentiation degree, and distant metastasis (p < 0.01, Table 3). The levels of CA199, CA242, and CEA in patients with high stage, low differentiation, or distant metastasis were clearly higher than those in patients with low stage, high and middle differentiation, and no distant metastasis (p < 0.01, Table 3).

Comparison of MDCT combined with CA199, CA242, and CEA in diagnosis of PC

The results of MDCT, CA199, CA242, and CEA in diagnosis of PC were compared with the pathological diagnosis (Table 4). The comparison of single and combined examination of MDCT, CA199, CA242, and CEA in diagnosis of PC was shown in Table 5. The sensitivity, accuracy, and negative predictive value of MDCT combined with CA199, CA242, and CEA in the diagnosis of PC were sharply higher than those of each single examination (p < 0.01).

### Table 1 Evaluation of preoperative staging of PC by MDCT

| MDCT | Surgical and pathological results |
|------|----------------------------------|
|      | Stage I | Stage II | Stage III | Stage IV |
| Stage I | 7 | 5 | 0 | 0 |
| Stage II | 3 | 17 | 4 | 0 |
| Stage III | 0 | 5 | 16 | 2 |
| Stage IV | 0 | 0 | 2 | 8 |
| Total | 10 | 27 | 22 | 10 |

### Table 2 Comparison of serum CA199, CA242, and CEA expression levels between the two groups

| Group      | Cases(n) | CA199 (U/mL) | CA242 (U/mL) | CEA(ng/mL) |
|------------|----------|--------------|--------------|------------|
| PC group   | 85       | 325.63 ± 85.24 | 269.42 ± 77.36 | 165.34 ± 46.84 |
| Control group | 39       | 42.32 ± 10.29 | 46.74 ± 12.23 | 13.96 ± 2.45 |
| t          | 20.642   | 17.45        | 20.136       |
| p          | < 0.01   | < 0.01       | < 0.01       |
Before treatment, the 2-year event-free survival rate in high expression group of serum tumor markers (CA199 > 418.06 U/mL, CA242 > 389.46 U/mL, CEA > 203.44 ng/mL) was significantly lower than the low expression group (CA199 ≤ 418.06 U/mL, CA242 ≤ 389.46 U/mL, CEA ≤ 203.44 ng/mL) ($\chi^2 = 9.746, 12.896, 10.212, p = 0.002, 0.000, 0.001, p < 0.01$, Figs. 3, 4, and 5).

**Table 3** Correlation analysis of CA199, CA242, CEA expression levels, and clinicopathological factors in PC group

|                | n   | CA199 (U/mL)       | CA242 (U/mL)       | CEA(ng/mL)        |
|----------------|-----|-------------------|-------------------|-------------------|
| Gender         |     |                   |                   |                   |
| Male           | 56  | 328.24 ± 88.23    | 265.87 ± 78.23    | 168.71 ± 43.20    |
| Female         | 29  | 320.59 ± 79.63    | 276.27 ± 80.02    | 158.83 ± 37.69    |
| Age (years)    |     |                   |                   |                   |
| < 60           | 37  | 318.88 ± 80.66    | 263.25 ± 68.24    | 163.22 ± 47.12    |
| ≥ 60           | 48  | 330.25 ± 92.24    | 274.17 ± 85.21    | 166.97 ± 49.20    |
| Tumor site     |     |                   |                   |                   |
| Head of pancreas | 55  | 330.29 ± 89.36    | 273.54 ± 79.32    | 167.23 ± 45.23    |
| Cauda pancreatitis | 30  | 323.83 ± 79.25    | 261.89 ± 75.62    | 161.88 ± 50.72    |
| Clinical stage |     |                   |                   |                   |
| I + II         | 53  | 165.98 ± 41.23    | 136.22 ± 36.78    | 96.41 ± 23.67     |
| III + IV       | 32  | 590.05 ± 132.54a  | 470.03 ± 126.34a  | 279.50 ± 67.82a   |
| Differentiation degree |     |                   |                   |                   |
| High and middle differentiation | 34  | 156.84 ± 39.66    | 149.83 ± 41.85    | 112.06 ± 36.78    |
| Low differentiation | 51  | 428.16 ± 116.24a  | 448.80 ± 113.65a  | 218.08 ± 64.27a   |
| Distant metastasis |     |                   |                   |                   |
| No             | 75  | 262.84 ± 62.30    | 217.37 ± 60.31    | 124.28 ± 32.64    |
| Yes            | 10  | 796.55 ± 196.33a  | 659.74 ± 156.79a  | 423.52 ± 102.39a  |

*a p < 0.01

**Table 4** The results of MDCT, CA199, CA242, and CEA in diagnosis of PC and pathological diagnosis

| Pathological diagnosis results | Malignant | Benign |
|-------------------------------|-----------|--------|
| MDCT                          | 69        | 5      |
| CA199                         | 61        | 6      |
| CA242                         | 58        | 4      |
| CEA                           | 55        | 5      |
| Combined detection            | 82        | 7      |

**Discussion**

At present, MDCT has become the first choice for diagnosis, tumor staging and treatment planning of PC [10]. MDCT is a method to display the structure of tumor lesions by imaging the density difference between lesions and tissues [11]. MDCT in the diagnosis of PC can clearly observe the location, size, enhancement, adjacent fat space, and relationship with surrounding tissues, as well as pancreatic lymph node metastasis, vascular infiltration, and distant metastasis, which has certain advantages for preoperative evaluation of clinical stage [12]. All the patients in this study presented iso-density or low-density on MDCT plain scan, and the tumor density was similar to that of pancreatic parenchyma, so it was easy to miss diagnosis by plain scan. When dynamic enhanced scan was performed, the enhancement of the lesion was not obvious and showed a low-density shadow, while the surrounding pancreas was significantly enhanced and the density was relatively uniform, which made the outline and morphology of the tumor more clear [13].

The main reasons for misdiagnosis in this study may be that the lesions were small and easy to be missed. On the other hand, some tumors were difficult to be accurately located and may show atypical imaging manifestations. For example, in two cases of mass pancreatitis,
the lesions were located in the head of the pancreas, and the lesions were compressed into the common bile duct and pancreatic duct, resulting in double duct sign. The other two patients had obvious low-density lesions on plain scan, and the enhancement pattern on enhanced scan was similar to that of PC, thus causing misdiagnosis. Preoperative staging of patients with PC can provide an important basis for making an accurate surgical plan. The results of this study showed that the overall coincidence rate between preoperative clinical staging and postoperative pathological staging of MDCT was 69.57%, which was basically consistent with the previous report [14]. Although MDCT is of great value in the diagnosis of PC, the sensitivity of the lesion to a diameter smaller than 2 cm causes a certain degree of misdiagnosis.

As a simple and non-invasive diagnostic method, serum tumor markers have been widely used in the diagnosis and prognosis evaluation of various tumors. A large number of studies have shown that biomarkers related to PC have certain guiding significance for early diagnosis and prognosis assessment, including CA199, CA242, CA50, CEA, etc. [15]. CA199 is the most widely used and effective tumor marker in the diagnosis of PC, and was once known as the ‘gold marker’ in the diagnosis of PC [16]. CA199, a Lewis

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**Table 5**  Comparison of single and combined MDCT, CA199, CA242, and CEA in diagnosis of PC

| Index          | Sensitivity      | Specificity     | Accuracy        | Positive predictive value | Negative predictive value |
|----------------|------------------|-----------------|-----------------|---------------------------|---------------------------|
| MDCT           | 81.18 (69/85)    | 87.18 (34/39)   | 83.06 (103/124) | 92.86 (69/71)             | 68.18 (34/50)             |
| CA199          | 71.76 (61/85)    | 84.61 (33/39)   | 75.81 (94/124)  | 91.04 (61/67)             | 57.89 (33/57)             |
| CA242          | 68.24 (58/85)    | 89.74 (35/39)   | 75.00 (93/124)  | 93.55 (58/62)             | 56.45 (35/62)             |
| CEA            | 64.71 (55/85)    | 87.18 (34/39)   | 71.77 (89/124)  | 91.67 (55/60)             | 53.13 (34/64)             |
| Combined detection | 96.47 (82/85) | 82.05 (32/39)   | 91.94 (114/124) | 92.13 (82/89)             | 94.12 (32/34)             |
| \( \chi^2 \)   | 35.791           | 1.118           | 19.864          | 0.415                     | 17.056                    |

\( a < 0.01, \) compared with MDCT group; \( b < 0.01, \) compared with CA199 group; \( c < 0.01, \) compared with CA242 group; \( d < 0.01, \) compared with CEA group

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**Fig. 3**  Comparison of 2-year event-free survival curve between the CA199 high expression group and the low expression group
**Fig. 4** Comparison of 2-year event-free survival curve between the CA242 high expression group and the low expression group.

**Fig. 5** Comparison of 2-year event-free survival curve between the CEA high expression group and the low expression group.
blood group antigen, is significantly increased in the serum of PC patients [17]. However, CA199 was also increased in biliary tract obstruction, pancreatitis, and other digestive tract tumors, which limits its clinical application. Therefore, CA199 cannot be used as a separate indicator to distinguish PC from benign pancreatic diseases [18]. In addition, some people lack Lewis-a blood group antigen gene and do not express CA199. Even if PC occurs, they cannot synthesized CA199 resulting in false negative [19]. CA242 is mainly expressed in pancreatic and colon malignant tumors [20]. Serum CA242 level was increased in patients with PC, especially in patients with pancreatic head cancer [21]. CA242 expression was not affected by bile secretion and Lewis antigen [22]. Additionally, studies have shown [23] that CA242 was rarely expressed in patients with acute pancreatitis and biliary benign diseases, and basically not affected by acute pancreatitis and cholecystosis, so it can be used as a marker related to the diagnosis of PC. CEA, as a broad-spectrum tumor marker, is involved in cell adhesion and only exists in trace in serum of healthy persons [24]. CEA is widely used as a biomarker for colorectal cancer, but about 60% of patients with PC have elevated serum CEA level. Although the practical frequency is not as high as CA199, CEA can be used as an auxiliary diagnostic indicator for PC combined examination [25], especially in judging the recurrence and metastasis of PC [26]. Our study found that the levels of serum CA199, CA242, and CEA in PC group were clearly higher than those in control group. The levels of CA199, CA242, and CEA in PC group were not significantly correlated with age, sex, and tumor site, but were notably correlated with tumor size, differentiation degree, clinical stage, and metastasis. However, as an in vitro diagnostic test, the detection of tumor markers is prone to false positive and false negative due to the influence of internal and external factors, so it should be combined with imaging.

Conclusion
To sum up, both imaging and serological examinations have their own advantages and disadvantages. MDCT combined with serum tumor markers in the diagnosis of PC can complement and confirm each other, significantly improve the sensitivity and accuracy compared with single examination, and have guiding significance for preoperative and prognostic evaluation.

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Authors' contributions
JS conceived and designed the study, and drafted the manuscript. YW and HS collected, analyzed, and interpreted the experimental data. XY and SL revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Ethics Committee of Qilu Hospital (Qingdao), Cheeloo College of Medicine, Shandong University. Signed written informed consents were obtained from the patients and/or guardians.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
1 Department of Clinical Laboratory, Qilu Hospital (Qingdao), Cheeloo College of Medicine, Shandong University, Qingdao 266035, China. 2 Department of Clinical Laboratory, Chengyang People’s Hospital, Qingdao 266109, China. 3 Radiophysics Department, The Affiliated Qingdao Central Hospital of Qilu University, The Second Affiliated Hospital of Medical College of Qingdao University, Qingdao 266042, China. 4 Department of Endoscopic Diagnosis and Treatment, Qingdao Eighth People’s Hospital, Qingdao 266100, China. 5 Department of Hepatobiliary Pancreatic Surgery (I), Central Hospital Affiliated to Shandong First Medical University, Jinan 250013, China.

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