Pancreatology 12 (2012) 227–233

Contents lists available at SciVerse ScienceDirect

Pancreatology

journal homepage: www.elsevier.com/locate/pan

Original article

Preoperative vascular evaluation with computed tomography and magnetic resonance imaging for pancreatic cancer: A meta-analysis

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ARTICLE INFO

Article history:
Received 2 November 2011
Received in revised form
28 March 2012
Accepted 29 March 2012

Keywords:
Computed tomography
Magnetic resonance imaging
Pancreatic cancer
Vascular invasion
Sensitivity and specificity

ABSTRACT

Objectives: Vascular invasion (VI) is the most important factor in assessing operability for pancreatic cancer. The accuracy of preoperative vascular staging with computed tomography (CT) and magnetic resonance imaging (MRI) was examined using meta-analysis.
Methods: Published articles in pancreatic cancer comparing diagnostic accuracy of CT with MRI for VI confirmed on histology were searched from MEDLINE, EMBASE and ISI Web of Science databases. Pooled sensitivity, specificity, likelihood ratio, summary receiver operating characteristic (SROC) curve and area under curve (AUC) were analysed by SPSS 13.0 and Revmen 5.1.
Results: Eight studies ($n = 296$) met the inclusion criteria. The pooled sensitivity of CT and MRI in diagnosing VI was 71% (95% CI, 64–78) and 67% (95% CI, 59–74), pooled specificity 92% (95% CI, 89–95) and 94% (95% CI, 91–96), positive likelihood ratio 6.33 (95% CI, 4.51–8.87) and 6.58 (95% CI, 4.62–9.37), negative likelihood ratio 0.34 (95% CI, 0.27–0.43) and 0.38 (95% CI, 0.30–0.47), and AUCs 0.87 and 0.76 ($p = 0.63$), respectively. There was no significant difference between CT and MRI for preoperative diagnosis of VI. Subgroup analysis of 4 studies ($n = 143$) showed no significant difference between CT and MRI in preoperative diagnosis of venous or arterial invasion ($p = 0.73$ and $p = 0.81$, respectively). When CT was compared with MRA in 3 studies ($n = 110$), again there was no significant difference for preoperative staging of VI ($p = 0.54$).
Conclusions: Both CT and MRI are underreporting vascular invasion preoperatively in pancreatic cancer. MRA does not add any additional information on vascular staging when compared with CT and MRI.

1. Introduction

Pancreatic cancer ranks the sixth most common cancer and forth cause of death from cancer in the western world, with a poor 5-year survival rate [1,2]. Surgical resection remains the only chance for cure with the best 5-year survival rate ranging from 25% to 5% for pancreatic adenocarcinoma [3–5]. Besides metastatic disease, vascular invasion is the most important and frequent factor precluding surgical resection, present in 21%–64% of cases [5–7]. Furthermore, vascular invasion is also an important predictor for poor prognosis after local resection [8,9]. To increase the number of cases for surgery, vascular resection and reconstitution are commonly performed in major pancreatic centres [8–11]. As a result, an accurate diagnosis of vascular invasion preoperatively is crucial in determining treatment modalities.

Computed tomography (CT) and magnetic resonance imaging (MRI) are the most commonly used image modalities for preoperative staging of pancreatic cancer. There remains controversial in selection of either CT or MRI as an optimal imaging tool to decide vascular invasion in pancreatic cancer [11]. The aim of this meta-analysis is to compare CT with MRI in preoperative evaluation of vascular invasion in patients with pancreatic cancer.

2. Materials and methods

The MEDLINE (via PubMed), EMBASE (via Ovid), and ISI Web of Science were searched systematically for all articles published between January 1990 and December 2010 using terms, computed

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1424-3903/$ – see front matter
doi:10.1016/j.pan.2012.03.057

tomography, CT, magnetic resonance imaging, MRI, pancreatic cancer, vascular, vessel, sensitivity and specificity. The "related articles" function was used to broaden the search, as well as performing the search using truncated search terms utilizing the wildcard ("*") character, and articles were also identified by manual searching of the references of included studies. All abstracts, studies, retrieved meta-analyses, systematic reviews and citations scanned were reviewed. English language restrictions were made.

2.1. Study selection

Inclusion criteria were: (1) both CT and MRI were used as preoperative diagnostic tools for vascular invasion in pancreatic cancer; (2) data on radiological diagnosis for vascular invasion were provided accurately and confirmed by surgery and/or pathology; and (3) enough information on absolute numbers of true positive, false positive, false negative, and true negative cases or their equivalents were available to construct 2×2 tables.

Exclusion criteria were: (1) only CT or MRI was used as preoperative diagnostic tool; (2) vascular invasion could not be confirmed by surgery or pathology; and (3) incomplete data to construct 2×2 tables.

2.2. Data extraction and quality assessment

Two of the investigators (Zhang YJ and Huang J) reviewed all the reported studies independently. Data were extracted according to endpoints, including true positive (TP), false positive (FP), false negative (FN), true negative (TN), sensitivity, specificity, positive likelihood ratio and negative likelihood ratio.

True positive (TP) was defined as the number of patients that had VI diagnosed by CT/MRI and subsequently confirmed by surgery/pathology. True negative (TN) was patients who had negative VI on CT/MRI and subsequently confirmed by surgery/pathology. False positive (FP) was patients diagnosed with VI on CT/MRI but not by surgery/pathology. False negative (FN) was failures of CT/MRI to predict VI but confirmed by surgery/pathology. The sensitivities and specificities of individual study were extracted and calculated by using 2×2 contingency tables for each end-point. Sensitivity was defined as the proportion of patients with VI who had the correct diagnosis of VI on CT/MRI (TP/(TP + FN)). Specificity was defined as the proportion of patients without VI who had the correct diagnosis of no VI on CT/MRI (TN/(FP + TN)). The likelihood ratio (LR) is the likelihood of VI confirmed by surgery/histology in patients with a preoperative diagnosis of VI on CT/MRI compared with those without VI. Positive likelihood ratio (PLR) is sensitivity/(1 − specificity) and negative likelihood ratio (NLR) (1 − sensitivity)/specificity.

Two reviewers (Zhang YJ and Huang J) independently assessed the methodological quality of each included study using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) tool developed by the NHS Centre for Reviews and Dissemination at the University of York, UK (Whiting 2003) [12]. Any disagreements were resolved by consensus or arbitration. For each individual study, the agreed results of the quality assessment were tabulated.

2.3. Statistical analysis

Meta-analysis for the accuracy of CT and MRI was performed by calculating pooled estimates of sensitivity and specificity. Pooling was conducted by both the Mantel–Haenzel test (fixed effects model) and the DerSimonian Laird test (random-effects model). The confidence intervals (CIs) were calculated using the *F* distribution method. For 0 value cells, 0.5 was added as described by Cox. The homogeneity of the sensitivities and specificities was tested by the likelihood ratio test. The homogeneity of likelihood ratios and diagnostic odds ratios was tested using Cochran's *Q* test on the basis of the inverse variance weights. Heterogeneity among the studies was tested by using summary receiver operating characteristic (SROC) curve, which was also used to calculate the area under the curve (AUC). SROC curve provides graphic display of diagnostic accuracy by plotting sensitivity versus one minus specificity and accounts for differences in diagnostic threshold among studies.

All statistical analyses were performed by SPSS 13.0 (SPSS Company, Chicago, Illinois, USA) and Review Manager Version 5.1 (The Cochrane Collaboration; Software Update, Oxford, UK).

3. Results

3.1. Search results and study selection

A total of 77 relevant articles were extracted and reviewed by 2 independent reviewers. Eight studies [13–20] ($n = 296$), including 4 prospective and 4 retrospective studies, that met the inclusion criteria were included in this analysis. The methodological qualities of these studies were of moderate quality, and all of them fulfilled at least 8 of the 13 items (Fig. 1). All studies used surgical and/or histological finding as a "gold standard" diagnosis of vascular invasion. The details of individual studies were showed in Table 1.

3.2. Diagnostic performance of CT and MRI

The pooled sensitivity of CT and MRI in diagnosing VI was 71% (95% CI, 64–78) and 67% (95% CI, 59–74), and the pooled specificity 92% (95% CI, 89–95) and 94% (95% CI, 91–96), respectively. The positive likelihood ratio of VI using CT and MRI for preoperative staging was 6.33 (95% CI, 4.51–8.87) and 6.58 (95% CI, 4.62–9.37), the negative likelihood ratio 0.34 (95% CI, 0.27–0.43) and 0.38 (95% CI, 0.30–0.47), respectively. There was no significant difference for sensitivity or specificity comparing CT with MRI for preoperative evaluation of VI ($p > 0.05$, Fig. 2).

For CT diagnosis, the SROC curve showed a *Q* value of 0.80 ± 0.04 and an AUC (area under curve) of 0.87 ± 0.04. For MRI diagnosis, the SROC curve showed a *Q* value of 0.70 ± 0.05 and an AUC of 0.76 ± 0.06. There was no significant difference between CT and MRI ($p = 0.63$, Fig. 3). Both modalities offered a similarly good diagnostic accuracy for VI. The heterogeneity for all the pooled accuracy estimates was not significant ($p > 0.05$).

Subgroup analysis of 4 studies ($n = 143$) with information on venous and arterial invasion showed the pooled sensitivity of CT and MRI for venous invasion was 70% (95% CI, 60–80) and 67% (95% CI, 56–77) and specificity 85% (95% CI, 77–90) and 90% (95% CI, 83–94), respectively. When compared CT and MRI for arterial invasion, the pooled sensitivity was 68% (95% CI, 56–79) and 68% (95% CI, 55–79), and specificity 93% (95% CI, 89–96) and 93% (95% CI, 89–96), respectively (Fig. 4). There was no significant difference between CT and MRI for preoperative evaluation of venous or arterial invasion ($p = 0.73$ and $p = 0.81$, respectively) (Fig. 5).

Three studies ($n = 110$) included magnetic resonance angiography (MRA). A subgroup analysis of these 3 studies compared with CT revealed that the pooled sensitivity was 72% (95% CI, 59–85) and 77% (95% CI, 65–86), and the pooled specificity 94% (95% CI, 89–98) and 96% (95% CI, 94–98), respectively. The SROC curve showed a *Q* value of 0.83 ± 0.09 and an AUC of 0.90 ± 0.08 for CT, and a *Q* value of 0.93 ± 0.02 and an AUC of 0.98 ± 0.01 for MRA, respectively, indicating the diagnostic accuracy for CT and MRA was similar. There was no significant difference between CT and MRA for preoperative evaluation of VI ($p = 0.54$, Fig. 6).