Mri scan for pulmonary embolism: a meta-analysis

Title: Diagnostic performance of magnetic resonance imaging for pulmonary embolism: a meta-analysis

Highlights:

1. This study was performed to analyze the diagnostic performance of MRI for PE.
2. High sensitivity and specificity of MRI diagnosis for PE was proved.
3. MRI diagnosis had low missed diagnosis and misdiagnosis rates in detecting PE.
4. MRI had strong discriminative ability for confirming PE.
5. Good diagnostic performance of MRI for PE was proved.

Abstract

Objective: The aim of this meta-analysis was to analyze the diagnostic performance of magnetic resonance imaging (MRI) forpulmonary embolism (PE).

Methods: A systematic literature search was conducted up to November 2013 by using the electronic databases and paper literatures. The 14-item quality assessment of diagnostic accuracy studies (QUADAS) list was used to evaluate the quality of the studies. Meta-disc software version 1. 4 was used to analyze the data. CT was used as “ gold standard”.

Results: Finally, 5 eligible literatures were included in this meta-analysis. Sensitivity in each study ranged from 78% to 100% and specificity ranged from 99% to 100%. The pooled estimate of sensitivity (83%, 95%CI: 78%-88%) and specificity (99%, 95%CI: 98%-100%) demonstrated that MRI diagnosis had high sensitivity and specificity in the detection of PE. The pooled estimate of positive likelihood ratios (PLR) (70. 22, 95%CI: 29. 04-

169. 76) and negative likelihood ratios (NLR) (0. 19, 95%CI: 0. 14-0. 25) provided evidence for low missed diagnosis and misdiagnosis rates of MRI diagnosis for PE. The strong discriminative ability of MRI for confirming PE was proved by the overall diagnostic odds ratio (DOR) (448. 98, 95%CI: 163. 47-1233. 18) and the summary receiver operating characteristic (SROC) curves (AUC= 0. 9852±0. 0052) demonstrated the superior diagnostic performance of MRI.

Conclusions: In conclusion, MRI is a diagnostic method of PE with the good diagnostic performance of high sensitivity and specificity, low missed diagnosis and misdiagnosis rates and strong discriminative ability.

Keywords: magnetic resonance imaging, diagnosis, pulmonary embolism, meta-analysis

Introduction

Pulmonary embolism (PE) is a common complication of deep vein thrombosis [1]. As a potentially fatal disorder [2], PE usually lead to death after right ventricular (RV) failure and circulatory collapse [3]. Early mortality for PE ranged from 5% in patients with stable clinical conditions to 58% in patients with cardiogenic shock [4]. At present, this mortality was still high. An recent study [5] published in 2013 reported that the mortality for PE was up to 67% in the patients with persistent hyponatremia. An accurate diagnosis of PE is the basis of the prevention and treatment of PE. However, missed diagnosis and misdiagnosis of PE is common in current clinical practice. Thus, to find the diagnostic methods with superior diagnostic performanceis an imperative study now.

With the development of the science and technology, more and more diagnostic methods are used to diagnosing PE. Such as electrocardiography (ECG) [6], chest X-ray[7], computed tomography (CT) [8] and magnetic resonance imaging (MRI) [9], they are all commonly used in the clinical diagnosis of PE. In the early 90s, The advent of spiral CT technology was aiming to change the diagnostic capability of PE [10]. Currently, CT is one of the most reliable and effective diagnostic methods for PE [11] and has been used as a “ gold standard” [12]. MRI is an established imaging modality in thoracic diseases [13] and ongoing technical developments have substantially improved the capability of MRI in the diagnosis for PE [14]. However, there was no enough evidence to validate MRI as an alternative diagnostic method to CT in patients with clinically suspected PE [15]. Therefore, we performed a meta-analysis to verify the good diagnostic performance of MRI for PE with CT as the “ gold standard”.

Methods

Search strategy

A systematic literature search was conducted up to November 2013 by using the electronic databases such as PubMed, Embase and Springer link. The keywords included “ Pulmonary Embolism” and “ MR imaging” or “ MR” or “ MRI” or “ Magnetic Resonance Imaging” or “ Magnetic Resonance”. Furthermore, paper literatures were retrieved by manual search. Review articles and reference lists of retrieved articles were also inspected to find additional eligible studies.

Study selection

After the initial search, we imposed additional criteria as follows: (1) the trials involved MRIdiagnosis for PE; (2) the subjects were the patients with suspected PE and beyond 18 years of age; (3) CT was used as the “ gold standard”; (4) the data of true positive (TP), false positive (FP), true negative (TN) and false negative (FN) were contained or could obtain by calculation.

Studies were excluded if one of the following existed: (1) MRI examination was not conducted in 48h after CT examination, (2) the language of the study was not English, and (3) the literatures were reviews, letters and comments.

Data extraction and quality assessment

Two investigators independently extracted the data from all eligible studies according to the criteria listed above. Disagreements were resolved by discussion. The following information was extracted: the first author name, year of publication, region, age and gender of subjects, sample size, data of TP, FP, TN and FN, magnetic field intensity and MRI scan sequence.

We used 14-item quality assessment of diagnostic accuracy studies (QUADAS) list [16] to evaluate the quality of the studies. Due to the association of quality assessment with the description of the method and result in the literatures, low score was often obtained when the details of them were not reported. Thus, we used“ yes”, “ no” and “ not clear” as assessment standards rather than scores.

Statistical analysis

In this meta-analysis, Meta-disc software version 1. 4 [17]was used to analyze the data. Summary receiver operating characteristic (SROC) curve, sensitivity(Sen), specificity (Spe), positive likelihood ratios (PLR), negative likelihood ratios (NLR), diagnostic odds ratio (DOR) as well as their 95% confidence interval (CIs) were calculated to evaluate the diagnostic performance of MRI for PE. The higher the DOR, the stronger the diagnostic power ofMRI in the detection of PE [18]. The analysis of SROC curves was based on the data of Sen and Spe. The area under the curve (AUC) was used to quantitatively measure the performance of MRI. Superior diagnostic performance is proved if the AUC is close to 1 [19]. Cochran's Q and I^2 statistics ($I^2 > 50\%$) was used to test the heterogeneity of the pooled data of DOR, PLR and NLR. The heterogeneity of the pooled data of Sen and Spe were evaluated by using chi-square test and I^2 statistics ($I^2 > 50\%$). Threshold effect ($p < 0.05$) was evaluated by spearman correlation analysis [20].

Results

Literature search

After initial literature search and removing the duplicated articles, there were 1748 potential relevant literatures was remained. Among them, 1714 irrelevant articles were excluded by scanning the titles and abstracts. Among the remaining 34 literatures, 29 articles were removed. They included 7 reviews, 5 conferences, 4 non-English articles, 2 comments and 11 articles

without involving PE. After removing them, 5 eligible literatures [21-25] were included to do this meta-analysis.

Characteristic of included studies

The 5 included studies were published from 2006 to 2013. A total of 679 subjects aged from 18 to 82 were included. The studies were conducted in the regions of Germany [21], Canada [22], French [23], China [24] and USA [25]. The data of MRI scan sequence were reported in all included studies except the study of Stein et al. [25] and the gender of the subjects were also not reported in this study (Table 1).

Based on the results of quality assessment shown in Table 2, we knew that all included studies reported the content of first to 9th and 14th terms. The content of 12th terms was only reported in the study of Kluge et al. [21]. The content of 10th term was not reported in the study of Stein et al. [25] and Zhang et al. [24] and not clear in the study of Pleszewski et al. [22]. The content of 11th term was not reported in the study of Revel et al. [23] and Zhang et al. [24] and not clear in the study of Kluge et al. [21].

Performance assessment of MRI diagnosis

Forrest plots for sensitivity and specificity were shown in Fig. 2. For sensitivity, significant heterogeneity (P= 0. 0295, I^2 = 62. 8%) was found among the studies. Thus, the random-effects model was used to pool the data. Sensitivity in each study ranged from 78% to 100%. The pooled estimate of sensitivity was 83% (95%CI: 78%-88%). For specificity, there was no significant heterogeneity among the included studies. Thus, the data were pooled by fixed-effects model. Specificity in each study ranged from

99% to 100% and the pooled estimate was 99% (95%CI: 98%-100%). The above results demonstrated thatMRI had high sensitivity and specificity in the detection of PE.

Forrest plots forPLR and NLR were shown in Fig. 3. For PLR and NLR, no significant heterogeneity (PLR: P= 0. 4802, I^2 = 0. 0%; NLR: P= 0. 4258, I^2 = 0. 0%) was existed in the included studies. Then fixed effects model was used to pool the data. The pooled estimate of PLR (70. 22, 95%CI: 29. 04-169. 76) and NLR (0. 19, 95%CI: 0. 14-0. 25) provided evidence for the low missed diagnosis and misdiagnosis rates of MRI diagnosis for PE.

Forrest plot of the DOR and SROC curves were shown in Fig. 4. For DOR, no significant heterogeneity (P= 0. 9077, I^2 = 0. 0%) was found among the included studies. so fixed effects model was used to pool the data. The overall DOR was 448. 98 (95%CI: 163. 47-1233. 18). It demonstrated the strong discriminatory ability of MRI in the detection of PE. The SROC curves (AUC= 0. 9852±0. 0052) showedsuperior diagnostic performance of MRI and the result ofspearman correlation analysis indicated that there was no threshold effect (p= 0. 624).

Discussion

In this meta-analysis, we concluded that MRI, as a diagnostic method for PE, had the characteristics of high sensitivity and specificity. Based on the data of PLR and NLR, we knew MRI had low missed diagnosis and misdiagnosis rates in detecting PE. The overall DOR demonstrated the strong diagnostic ability of MRI diagnosis for PE. The AUC of SROC curves was close to 1 and it revealed the superior diagnostic performance of MRI.

MRI is a powerful imaging modality that provides internal images of materials and living organisms on a microscopic and macroscopic scale [26]. In MRI diagnosis, the image is constructed by magnetic resonance that is generated from the electromagnetic signals emitted by the protons of the body [27]. Compared to CT, MRI has three clear advantages. The first advantage of MRI is lack of exposure to ionizing radiation and no using of iodinated contrast media [21]. The second one is the capability of 3D-multiplanar imaging and simultaneous imaging of multiple sections [28]. Third, a variety of imaging parameters can be obtained to provide diagnostic information [29]. These advantages indicate that MRI diagnosis is reliable and safe in the detection of PE and may supplant the position of CT in future.

Some limitations of this meta-analysis have to be mentioned. First, the number of included studies and the sample size were small in this meta-analysis. Thus, the result of statistical analysis may be questioned. Second, for sensitivity, significantheterogeneity was found among the included studies. It is speculated that the potential sources of heterogeneity may be the differences of subjects, magnetic field intensity and MRI scan sequence. Thus, further studies need to be done to explore the sources of heterogeneity. Third, in this meta-analysis, only published literatures were included and there may be the omission of gray literatures. Thus, false-positive results may be obtained and the diagnostic performance of MRI may be exaggerated. In view of these limitations, the application of MRI diagnosis for PE must be prudentially promoted.

In conclusion, MRI is a diagnostic method of PE with the good diagnostic performance of high sensitivity and specificity, low missed diagnosis and

misdiagnosis rates and strong discriminative ability. With the improvement of technology and the increase of equipment performance, MRI will have a broad application prospect in the clinical diagnosis of PE in future.