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Major Article

Risk factors of neurosurgical site infection after craniotomy: A systematic review and meta-analysis

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Background: Neurosurgical site infection (SSI) is a complication related to craniotomy, which may lead to severe morbidity and higher hospital costs during the postoperative period.

Methods: Retrospective cohorts, case-control studies, or prospective investigations addressing risk factors of SSI updated until January 2017 were systematically searched in 2 databases (PubMed and Embase). The Newcastle-Ottawa Scale was used to evaluate quality of the included studies, heterogeneity was assessed by I^2 tests, and a funnel plot and Egger test were used for the evaluation of publication bias.

Results: There were 26 studies in total enrolled in this review. The results showed that the risk factors which had relation with SSI were other infection (odds ratio [OR], 5.42; 95% confidence interval [CI], 2.8-10.49), number of operations (>1) (OR, 2.352; 95% CI, 1.142-4.847), cerebrospinal fluid (CSF) leak (OR, 7.817; 95% CI, 2.573-23.751), CSF drainage (OR, 2.55; 95% CI, 1.58-4.11), duration of operation (>4 hours) (as for retrospective cohort studies) (OR, 1.766; 95% CI, 1.110-2.809), venous sinus entry (OR, 4.015; 95% CI, 1.468-10.982), American Society of Anesthesiologists score (>2) (OR, 1.398; 95% CI, 1.098-1.78), sex (male) (as for prospective investigations) (OR, 1.474; 95% CI, 1.013-2.145), and surgical reasons (nontraumatic) (OR, 2.137; 95% CI, 1.106-4.129).

Conclusions: According to the current analysis, all the factors mentioned were the risk factors for SSI after craniotomy. Patients with these risk factors should be paid more attention to prevent SSI. More evidence provided by high-quality studies is still needed to further investigate the risk factors of SSI.

Although there has been great progress in brain surgery technology, postoperative complications such as neurosurgical site infection (SSI) are still possible. Some studies have reported that 2.2%-4.7% of patients after craniotomy were complicated with SSI.[1,2] Although the incidence of SSI is low, it has major consequences, especially after craniotomy: SSI may develop the risk of reoperation; increase morbidity, mortality, cost, permanent sequelae, pain, and discomfort in the patients; and extend the length of hospital stay.[3] Therefore, it is quite necessary to evaluate the high-risk factors of SSI. At present, many studies have tried to identify these risk factors, among which the factors that have been reported are as follows: age, sex, duration of operation, operative sites, number of operation, surgical reasons, emergency procedures, cerebrospinal fluid (CSF) leakage, antibiotic prophylaxis, steroid use, CSF drainage, American Society of Anesthesiologists (ASA) score, and so forth. However, the inclusion criteria for these studies are diverse, and most of these studies are conducted to assess the specific types of infection that are specific to the population. Their results are often inconsistent.[4] Because of the inconsistency, conclusions could not be drawn on these risk factors. Therefore, we performed a systematic review and meta-analysis based on the current evidence, attempting to identify the risk factors of SSI. Through the estimation of the risk factors and the identification of high-risk groups, we can prevent the occurrence of SSI, improve patient outcomes, and reduce mortality, morbidity, and economic burden of health care.

MATERIALS AND METHODS

Types of participants and intervention

Patients after craniotomy (including craniectomy plus cranioplasty) were selected. The interventions were the various factors (exposure factors) for SSI, such as combination with other infection, CSF leakage, CSF drainage, venous sinus entry, duration of operation, and so forth.

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Literature search

A systematic search of PubMed (Medline) and Embase was performed by 2 investigators to identify all the related studies from inception to January 2017. The following keywords and/or corresponding Medical Subject Heading terms were used: risk factor or prognostic factor or epidemiologic factor; and neurosurgical site infection or meningitis; and craniotomy or neurosurgery or brain surgery. Two independent reviewers performed the search, with the limitation of publications in the English language. Manual searches of the references cited in all the relevant articles were also conducted. Disagreements were resolved by reaching a consensus, and a third reviewer was consulted if necessary. All analyses were based on previous published studies. Therefore, no ethical approval and patient consent were required.

Eligibility criteria

Studies enrolled in the meta-analysis must meet the following eligibility criteria: (1) retrospective cohorts, case-control studies, or prospective investigations assessing risk factors of SSI; (2) studies reporting (or enough data to calculate them) estimates of odds ratios (ORs), relative risks, or hazard ratios with their corresponding 95% confidence intervals (CIs); and (3) studies reporting in English. Those studies that were published for the same study population or unoriginal studies were excluded from the current systematic review. In the event of disagreement between the 2 reviewers regarding whether a study met the inclusion criteria, a consensus was reached by joint review.

Screening and data extraction

All articles identified by our search underwent a preliminary screening of their titles and abstracts to determine relevance and general adherence to the eligibility criteria. Data were extracted from the selected studies by 2 reviewers independently, including authors, published year, country in which the study was performed, study design, study institution, number of cases, study period, infection type, surgery type, and related risk factors. Any discrepancies were resolved through discussion among the authors.

Evaluation of research quality

The research quality of retained studies was assessed using the Newcastle-Ottawa Scale (NOS). Studies with an NOS score ≥7 were considered to be of high quality; studies with scores 4-6 were considered to be of moderate quality, and poor quality was judged if the score was <4.

Statistical analysis

The results which indicated the correlation between SSI and risk factors were evaluated as pooled ORs and corresponding 95% CIs. $P < .05$ (2-sided) was considered to be statistically significant. The heterogeneity of these studies was evaluated by I^2 tests. $I^2 < 25\%$ indicated low heterogeneity, 25%-50% indicated moderate heterogeneity, and >50% indicated a high degree of inconsistency. If there was statistical significance ($P < .10$) with heterogeneity, data analyses were performed using the random effects model; otherwise, the fixed effects model was used. The subgroup analyses were performed on the strength of study design, which were categorized into case-control study, prospective investigation, and retrospective cohort study. Additionally, to assess the potential publication bias, a funnel plot and Egger test were used.[5] All statistical analyses and tests were performed by STATA 12.0 (StataCorp, College Station, TX).

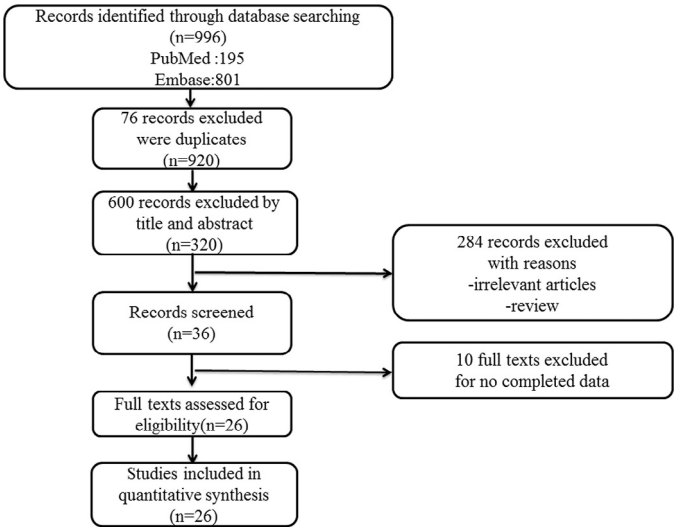

Fig 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram.

RESULTS

Search results and studies selection

After the electronic and manual searches according to our strategy, 996 articles were included. Figure 1 shows the process of the studies selection. First, 76 articles were excluded because of duplication, and then we excluded 600 articles after the screening of the titles and abstracts. Second, when the included records were screened, 284 articles were excluded, among which 48 were excluded for review, and 236 for irrelevance. After assessment of the full texts, 10 studies were excluded for no complete data.

Characteristics of studies

There were 26 eligible studies finally included in our meta-analysis, including 13 retrospective cohort studies, 8 prospective investigations, and 5 case-control studies. Among these, 12 studies were from Europe, 7 from the United States, 5 from Asia, and 2 from Africa. The basic characteristics of the enrolled studies are summarized in Table 1.

Characteristics of risk factors

A total of 21 risk factors were assessed in our meta-analysis. A funnel plot and Egger test were used for the potential publication bias evaluation. Generally, the P value of Egger test was >.05, indicating there was no evidence of publication bias in our meta-analysis (Table 2).

META-ANALYSIS RESULTS

Combination with other infection

Seven studies related to other infection (remote-site infections: bronchopneumonia, urinary tract infection, and blood infection) were included, including 2 case-control studies[6,7] and 5 cohort studies.[8-12] The pooled OR for other infection was 5.42 (95%