Review

Decompressive craniectomy in neurocritical care

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ABSTRACT

Recently, several randomized controlled trials (RCT) investigating the effectiveness of decompressive craniectomy in the context of neurocritical illnesses have been completed. Thus, a meta-analysis to update the current evidence regarding the effects of decompressive craniectomy is necessary. We searched PUBMED, EMBASE and the Cochrane Central Register of Controlled Trials. Other sources, including internet-based clinical trial registries and grey literature, were also searched. After searching the literature, two investigators independently performed literature screening, assessing the quality of the included trials and extracting the data. The outcome measures included the composite outcome of death or dependence and the risk of death. Ten RCT were included: seven RCT were on malignant middle cerebral artery infarction (MCAI) and three were on severe traumatic brain injury (TBI). Decompressive craniectomy significantly reduced the risk of death for patients suffering malignant MCAI (risk ratio [RR] 0.46, 95% confidence interval [CI]: 0.36–0.59, P < 0.00001) in comparison with no reduction in the risk of death for patients with severe TBI (RR: 0.83, 95% CI: 0.48–1.42, P = 0.49). However, there was no significant difference in the composite risk of death or dependence at the final follow-up between the decompressive craniectomy group and the conservative treatment group for either malignant MCAI or severe TBI. The present meta-analysis indicates that decompressive craniectomy can significantly reduce the risk of death for patients with malignant MCAI, although no evidence demonstrates that decompressive craniectomy is associated with a reduced risk of death or dependence for TBI patients.

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1. Introduction

As a leading cause of mortality and morbidity in the neurointensive care unit, increased intracranial pressure (ICP) has received considerable attention in clinical practice [1,2]. Various neurocritical illnesses, including malignant middle cerebral artery infarction (MCAI) and severe traumatic brain injury (TBI), lead to increased ICP and may result in cerebral herniation, death or permanent disability [3,4]. Unfortunately, although the well-known deleterious effects of increased ICP have long been recognized, medical and surgical interventions remain limited, and advances in treatment have been modest.

The current options for the management of increased ICP consist of conservative treatment or surgical decompression [5,6]. Generally, conservative treatment includes a set of medical interventions, including head elevation, sedation, hypothermia, hyperventilation, hyperosmotic agents, barbiturates and cerebrospinal fluid withdrawal [7,8]. However, although maximal conservative treatment is provided for patients with increased ICP in a variety of neurocritical illnesses, the risk of death and severe disability remains high and ranges from 50 to 80%, based on previous retrospective reviews or surgical decompression series [4,9]. This has led to increasing enthusiasm in exploring other potentially effective strategies, such as decompressive craniectomy, to obtain satisfactory ICP control and a favorable outcome for neurocritical care patients with refractory intracranial hypertension.

In recent years, decompressive craniectomy, as a second-tier therapeutic measure, has been a focus and appears to be a promising approach to control ICP [5,10–12]. It is postulated that decompressive craniectomy can allow brain tissue to expand, consequently facilitating control of increased ICP and reducing the risk of herniation, which may improve the outcome of neurocritical care patients. A recent systematic review involving patients who were 60 years of age or younger has revealed that

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surgical decompression can reduce the risk of death or severe disability following malignant MCAI [13,14]; another meta-analysis, including only one trial, failed to show a significant advantage for decompressive craniectomy to reduce an unfavorable outcome following severe pediatric TBI [15]. Recently, with the completion of several randomized controlled trials (RCT) involving malignant MCAI in older patients or severe TBI in adults, it is necessary to further compare the effects of decompressive craniectomy with conservative treatment in the management of neurocritical care patients with refractory intracranial hypertension.

The present meta-analysis was performed to determine whether decompressive craniectomy is effective in decreasing the risk of death or dependence when compared to conservative treatments in the treatment of neurocritical care patients with refractory intracranial hypertension, based on current evidence.

2. Materials and methods

2.1. Study identification

We performed a systematic review of the published literature to identify all clinical RCT in which decompressive craniectomy had been compared to conservative treatment for patients with neurocritical illnesses, including malignant MCAI or severe TBI confirmed by CT scan or MRI. Studies that were either not RCT or that did not directly involve the effects of decompressive craniectomy in neurocritical care patients with evidence of increased ICP or cerebral swelling, were eliminated.

2.2. Search strategy

Based on key words or medical subject heading terms, such as "decompressive craniectomy", "intracranial hypertension", "brain edema", "neurocritical care", "traumatic brain injury", "stroke", "cerebrovascular disorders", "intracranial hemorrhage", and "brain ischemia", an electronic search for relevant articles up to July 2014 was conducted in PUBMED, EMBASE and the Cochrane Central Register of Controlled Trials (CENTRAL) without language limitation. Moreover, the OpenGrey database (a System for Information on Grey Literature in Europe) and the USA National Technical Information Service (NTIS) were searched for grey literature. Internet-based clinical trial registries, such as ClinicalTrials.gov, International Clinical Trials Registry Platform and International Standard Randomized Controlled Trial Number Register, were also searched for suitable studies. In addition, abstracts and conference proceedings from the Web of Science were searched where available; we also complemented this by using the "Related Articles" function on PUBMED and searched the reference lists of relevant articles. For full details of the search strategy, see Supplementary Figure 1. The search was performed independently by two investigators and was completed in July 2014.

2.3. Literature screening

After the literature search, two investigators independently reviewed the titles and abstracts of all of the identified studies and excluded those that were obviously irrelevant or duplicates. The full articles of the remaining studies were then retrieved and independently reviewed using a structured form to determine eligibility and to extract data. Disagreements were resolved by discussion and consensus or by a third investigator if needed. We contacted the study authors for clarification and further information where necessary.

2.4. Quality assessment

The quality of eligible studies was formally evaluated using the Cochrane Collaboration's tool for assessing the risk of bias in randomized trials. Specifically, studies were judged on the following items: adequacy of random sequence generation, allocation concealment, blinding of outcome assessment, incompleteness of outcome data, possibility of selective outcome reporting and other biases. The risk of bias for each item was categorized as high, unclear or low and was scored as 0, 1, or 2, respectively. Studies with a total score of $\leqslant 6$ were considered to be low-quality; studies with a total score of $\geqslant 10$ were considered to be high-quality.

2.5. Data extraction

We extracted the following data from each study: baseline characteristics, design and objective, number of patients, timing of measurements, main results of the study, and follow-up results. The primary outcome assessed was the composite outcome of death or dependence in activities of daily living (ADL) at the end of the follow-up period (at least 6 months). The secondary outcome was death at the end of the follow-up period. In the present study, the cut-off points for the various scales to define dependence in ADL were a score of 3 or more on the modified Rankin Scale, a score of 60 or less on the Barthel Index, a grade of 3 or less on the Glasgow Outcome Scale and a grade of 4 or less on the Extended Glasgow Outcome Scale [16–18].

2.6. Statistical analysis

Considering the possibility that effectiveness may differ in different illnesses, statistical analyses were performed according to the types of neurocritical illness. A heterogeneity-based method of meta-analysis was performed using Review Manager (version 5.2, Cochrane Collaboration and Update Software) for prospective RCT. Heterogeneity between studies was assessed by means of the standard Cochran's Q statistic and I^2 statistic, which was pre-specified as $P < 0.10$ or $I^2 > 50\%$ in the present study. A summary risk ratio (RR) was used as the effect parameter for the meta-analysis, and the 95% confidence interval (CI) was used to interpret the results. A fixed-effect model was used to merge the values of the RR to estimate the overall effect size when heterogeneity between studies was not obtained. Otherwise, a random-effect model was used in the statistical analysis. All of the tests were two-sided, and statistical significance was defined as a probability value of <0.05 if not specifically stated.

3. Results

3.1. Characteristics of included studies

In total, 907 articles were initially identified, and 897 articles were excluded, leaving 10 studies for final analysis. Figure 1 shows the flow diagram of the search results and study selection.

All 10 included studies were prospective RCT [19–28]. A total of 543 participants were enrolled in the 10 trials; of these, 263 (48.4%) patients were included in the group with decompressive craniectomy treatment. All of the included trials had distinct inclusion criteria and exclusion criteria. Each trial described the baseline characteristics of the enrolled participants. There were no significant differences in the baseline characteristics of participants between the groups in these trials other than the Jüttler [22] and Slezins [25] studies. Table 1 summarizes the baseline data of the 10 included trials.