Assessment of outcome following decompressive craniectomy for malignant middle cerebral artery infarction in patients older than 60 years of age

A review

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Object. Decompressive surgery can be life saving after malignant cerebral infarction. However, severe residual disability occurs in a significant number of surviving patients. Most discussion about the benefits of surgery is based on studies performed in patients who are ≤60 years of age. Less is known about the benefits of the procedure in the elderly population. The authors undertook a review of the literature on decompressive craniectomy for malignant cerebral infarction and compared the mortality and outcome data published in patients older and younger than 60 years of age. The authors discuss their analysis, with specific reference to the limitations of the studies analyzed, the outcome measures used, and the special considerations required when discussing stroke recovery in the elderly.

Methods. Studies on decompressive craniectomy for malignant middle cerebral artery infarction reported in the English literature were analyzed. A cutoff point for age of >60 or ≤60 years was set, and the study population was segregated. No studies specifically analyzed patients >60 years old. A total of 19 studies was identified, 10 of which included patients who were >60 years of age. A comparison between the 2 age groups was made within the 10 studies and also among all the patients in the 19 studies. Mortality rates and outcome scores were assessed for each study, and a Barthel Index (BI) score of <60 or a modified Rankin Scale (mRS) score of >3 was considered to represent a poor outcome. Rates were compared using the Fisher exact test, and p values <0.05 were considered statistically significant.

Results. Nineteen studies were found, which included 273 patients undergoing decompressive craniectomy for malignant cerebral infarcts. Ten of these studies included 73 patients (26.7%) who were >60 years of age. The mean follow-up times ranged from 5.75 to 12.3 months in the >60-years group and 4.2 to 28 months in the ≤60-years group. The mortality rate was significantly higher, at 51.3% in the >60-years group (37 of 72 patients) compared with 20.8% (41 of 197 patients) in the ≤60-years group (p < 0.0001). Similarly, patients who survived in the >60-years group had significantly higher rates of poor outcomes, at 81.8% (27 of 33), compared with 33.1% (47 of 142) in the ≤60-year-old group (p < 0.0001). The BI was the most commonly used primary outcome measure (15 out of 19 studies), followed by the mRS score, which was used in 4 studies.

Conclusions. The mortality rate and functional outcome, as measured by the BI and mRS, were significantly worse in patients >60 years of age following decompressive craniectomy for malignant infarction. Age is an important factor to consider in patient selection for surgery. However, cautious interpretation of the results is required because the outcome scores that were used only measure physical disability, whereas other factors, including psychosocial, financial, and caregiver burden, should be considered in addition to age alone. (DOI: 10.3171/2009.3.FOCUS0958)

Key Words • decompressive craniectomy • infarction • stroke • age • elderly population

Among cases of supratentorial infarction, 10–15% involve the entire MCA territory.1,14,22,45 Despite optimal medical therapy, the mortality rate approaches 80%. This type of extensive stroke has been termed malignant MCA infarction and is accompanied by severe brain edema, leading to raised ICP and subsequent brain herniation.11 A vicious cycle develops as the resulting ischemic insult leads to further edema, and thus to increases in ICP and reduction of regional cerebral blood flow.15 Medical treatment has not been shown to be effective.16

Several experimental studies7,9 have shown the benefit of decompressive craniectomy in rats after MCA occlusion. In these studies, craniectomy resulted in im-
proved outcome, and, if treated early enough, reduced infarction size. In 1956, Scarcella first described the surgical removal of a large bone flap (frontotemporal-parietal) with duraplasty ipsilateral to the infarction to reduce ICP and prevent brain herniation. Since then, there have been several case series and reports indicating improved survival and functional outcome. Recently, 3 randomized controlled trials were performed to study the effects of decompressive craniectomies after malignant stroke. The pooled analysis of these trials confirmed the suggestions from nonrandomized studies that decompressive craniectomy undertaken within 48 hours of stroke onset reduces mortality rates and increases the number of patients with a favorable functional outcome after malignant hemispheric infarction.

However, fundamental questions remain unanswered. The importance of preoperative neurological status, hemispheric dominance, timing of surgery after onset of stroke, and patient age are a few factors that may affect outcome. The pooled results from the 3 recent controlled trials included only patients ≤ 60 years of age. In their multivariate regression analysis studies, Gupta et al. and Chen et al. showed that age was the only variable found to be significant in the outcome of decompressive hemi-craniectomy after malignant MCA infarction. Hence, despite the positive outcome demonstrated by these controlled trials, it is controversial how applicable the results are to patients > 60 years of age. In addition, outcome measures may produce different results depending on patient age, and these results must be interpreted cautiously. We review the studies in which patients > 60 years of age who underwent decompressive craniectomies for hemispheric infarction were analyzed.

**Methods**

A PubMed search for studies reported in the English language after 1970 was performed using the key words “craniectomy” or “hemicraniectomy” in several combinations with the key words “stroke,” “ischemia,” and “malignant middle cerebral artery infarction.” We included the studies in which information was available for individual patients. Mortality rates and outcome scores were assessed for each study group. Because the recent controlled trials all included patients < 60 years old, we specified the cutoff point for age as > 60 or ≤ 60 years. We considered a BI score of < 60 or an mRS score of > 3 to represent poor outcome, as suggested elsewhere. GraphPad Instat version 3.05 (GraphPad Software, Inc.) was used for statistical analysis. Rates were compared using the Fisher exact test, and p values < 0.05 were considered statistically significant.

**Results**

Nineteen studies were identified in the English literature, and 10 included patients > 60 years of age. There were 273 patients for whom individual information on age, side of infarction, outcome scores, and survival were available. Seventy-three patients (26.7%) were > 60 years of age. The right/left hemisphere infarction ratio was 60:13 in the > 60-year-old group, and it was 148:51 in the ≤ 60-year-old group. Early surgery (< 24 hours postadmission) was performed in 19 (26.8%) of 71 patients in the > 60-year-old group and in 60 (36.6%) of 164 in the ≤ 60-year-old group. The mean follow-up times ranged from 5.75 to 12.3 months in the > 60-year-old group and 4.2 to 28 months in the ≤ 60-year-old group (Tables 1 and 2).

The mortality rates in the > 60-year-old group were significantly higher, at 37 (51.3%) of 72, compared with 41 (20.8%) of 197 in the ≤ 60-year-old group (p < 0.0001, Fig. 1). Similarly, among patients who survived, poor outcomes were significantly higher in the > 60-year-old group.
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We also analyzed patient data derived only from the 10 studies that included both age groups to minimize bias and confounding factors when analyzing all 19 studies. Again, the mortality rate was significantly higher in the > 60-year-old group (51.3%) compared with 23% (30 of 130) in the ≤ 60-year-old group (p < 0.0001, Fig. 3). Similarly, patients who survived in the > 60-year-old group had significantly higher rates of poor outcomes—81.8% compared with 32% (31 of 97) in the ≤ 60 group (p < 0.0172, Fig. 4).

Although a higher proportion (45%) of patients > 60 years old who had surgery within 24 hours of stroke onset showed good outcome, compared with 14% in those who underwent surgery after 24 hours, the results were not statistically significant.

In 15 of 19 studies the BI was primarily used to measure outcome, whereas in 4 studies the mRS was used.

**Discussion**

Decompressive surgery with duraplasty has been performed in patients with malignant brain edema caused by infarction or trauma. The aim of the procedure is to decrease the mass effect of the edema, preventing brain herniation, secondary injury to the brain, and death. The benefits of early surgery after malignant infarction have been shown in experimental studies in rats, and encouraging results both in mortality rates and functional outcome have been shown by several authors worldwide. However, the importance of age in functional outcome, especially in the older population, has been less well established.

Recently, 3 European randomized controlled trials (the French DECIMAL trial, the German DESTINY tri-
al, and the Dutch HAMLET trial) published their pooled analysis of 93 patients, all < 61 years of age. This showed that hemicraniectomy reduced the mortality rate by 50% at 1 year when compared with best medical treatment. This confirms the results from previous nonrandomized studies and case reports analyzed in this review. The question arises whether similar results would be expected in an older patient population, because the incidence of stroke increases with age, and large hemispheric strokes also occur in patients > 60 years of age.

In their retrospective analysis, Yao et al.\textsuperscript{46} specifically compared results between younger (≤ 60 years old) and elderly patients (≥ 60 years old) after decompressive craniectomy, and showed a mortality rate of 7.7 and 33.3%, respectively. The 10 studies we analyzed, which included patients > 60 years of age, showed that the mortality rate was also significantly higher, at 51.3%, compared with the younger population. The latter had a mortality rate of 20.8%, which was similar to the rate of 22% reported in the pooled analysis. Decisions for surgery based on survival benefits are therefore less clear-cut in patients in the group older than 60 years, even though the mortality rate is 80% without surgery.\textsuperscript{1,11}

Despite the comparable survival and mortality rates after decompressive surgery in patients > 60 years of age, information on the risk of death is relatively straightforward to convey to relatives. However, discussion of surgery after a large stroke is not usually based on survival benefits and more importantly on functional outcome. One of the main difficulties for families and physicians is to ascertain whether the patient will have acceptable residual disability and a good quality of life. This difficulty is compounded by the fact that family and patient perceptions of quality of life vary. Moreover, the inability to predict with certainty the degree of residual disability and the absence of the patient’s participation in the decision-making process add to the difficulty.

In the pooled European randomized controlled trials analysis of patients < 61 years of age it was demonstrated that more patients in the surgery group (43 vs 21%) survived with moderate disability (mRS score of ≤ 3: able to walk without assistance), but there were also more patients (31 vs 2%) who survived with moderately severe disability (mRS Score 4). The number of patients with residual severe disability (mRS Score 5) was not increased following decompressive craniectomy and remained ~ 5%. Our analysis of all 19 studies discussed here showed poor outcome following surgery in 33.1% of patients < 60 years of age, which is similar to the 35% shown in the pooled controlled studies. However, poor outcome was significantly higher in patients in the > 60 group, at 81.8%. Despite the statistical limitations of this analysis, these results are discouraging, making it difficult to recommend decompressive surgery for malignant stroke in most patients > 60 years of age.

In previous reports age has been suggested as a key factor in determining who will benefit from decompressive surgery after malignant cerebral infarct,\textsuperscript{10,38} and some investigators have reported poorer outcomes in elderly patients.\textsuperscript{46} Increasing age has also been shown to be an important factor in poor recovery after stroke.\textsuperscript{29} This may be due to the diminished capacity for neuroplasticity in elderly patients.\textsuperscript{29} In addition, preexisting disability and severe comorbid conditions are also important factors that increase poor outcome, and both are more prominent in elderly patients.

However, a cutoff age of 60 years is clearly arbitrary, and surgical decisions must be made on an individual basis. Moreover, there is much controversy over whether age per se is as important a predictor of outcome as other factors, such as admission functional status, cognitive status, and social situation, including the availability of resources or employment. Indeed, many would advocate that advanced age should not be regarded as a limiting factor to rehabilitation after stroke.\textsuperscript{6,26,28}

We have shown here the differences in mortality rates and outcomes between the > 60-year-old and ≤ 60-year-old patients following decompressive surgery for malignant stroke. We have also alluded to the fact that outcome is a more complex measure than mortality rate. “Good outcome” in these studies was measured primarily by the BI and the mRS, indicating a level of disability or “activity” levels as defined by the International Classification of Functioning.\textsuperscript{44} However, what disability means and how
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it is ultimately measured are debatable. The BI and mRS, although widely used as basic standard measures, have gross limitations when determining activity level. The BI correlates highly with motor ability and physical disability, leaving cognitive and psychological consequences common to stroke as predictors of a poor outcome potentially neglected. Furthermore, the BI and mRS have been shown to be inconsistent indicators of independence due to the lack of consensus between measures, which calls into question the clinical and research utility of the BI and mRS to measure perceptions of disability, independence, and participation.

Predicting outcomes for older adults after stroke has revealed complex and contextual factors that could not be assessed using the BI or mRS; these included depression, cognitive functioning, and demographic and economic factors. The ability to perform activities of daily living declines with age, putting potentially elderly caregivers and stroke survivors at greater risk because of the task of caring and of strain on the caregiver. Therefore, the presence of strong family support and the impact on the caregiver may be at least as important as age per se when considering decompressive surgery following malignant stroke.

There are several limitations in our review. The data are mostly obtained from previous case series and retrospective studies, and thus the standard meta-analysis techniques could not be applied. There is heterogeneity in the population analyzed, which limits the scope of this study. In addition, the patients did not have a uniform approach in terms of follow-up and management. We also need to take into account that there is publication bias favoring good outcomes in the literature. Despite all these limitations, this review has highlighted the difference in mortality rates and outcome scores between the > 60-year-old and ≤ 60-year-old patients following decompressive surgery for malignant stroke, and cautious interpretation of these results is required.

Any definitive conclusion will require a randomized controlled study to assess the benefits of decompressive surgery specifically in elderly patients. The study would similarly compare surgery against best medical treatment, with mortality rates and clinical outcome as primary end points. The outcome measure should use a stroke- and age-sensitive assessment tool such as the Stroke Impact Scale and the Assessment of Motor and Process Skill. These tools are more rigorous than both the BI and the mRS score. The Assessment of Motor Process Skills requires formal training, and both measures are less susceptible to scorer variability. Moreover, they can be used to measure the severity of disability and participation restriction after stroke in a way pertinent to the patient’s age and lifestyle.

Elderly patients are also more likely to have multiple factors that can contribute to outcome following a stroke. Analysis of occupation and economic factors, cognitive level, level of activities of daily living, and family support status are a few factors that would be of particular interest to assess in this population in any future studies.

Conclusion

Decompressive craniectomy is a life-saving procedure after malignant brain infarction, but the selection of patients for decompressive surgery remains controversial. Age may be a key factor in helping guide surgical decisions because elderly patients have a significantly higher mortality rate and do worse after decompressive surgery. However, factors other than age should be considered, and the treatment decision should be individualized. The BI and mRS systems are crude measures of physical domains of disabilities only, and patients with severe neurological deficits with decreased quality of life cannot be evaluated thoroughly by them. The psychosocial and financial burden of care, which may not be related solely to physical disability, should also be taken into account when determining outcome in the elderly.

Disclosure

This work was supported in part by Russell and Elizabeth Siegelman, Bernard and Ronni Lacroute, and the William Randolph Hearst Foundation (GKS).

References


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Neurosurg. Focus / Volume 26 / June 2009

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