Outcome and Cost of Aneurysmal Subarachnoid Hemorrhage

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KEYWORDS

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Aneurysmal subarachnoid hemorrhage (aSAH) is a neurosurgical disaster. Few conditions in neurosurgery consume so many resources, with such a relatively poor outcome, as does aSAH. Of the patients who present with aSAH, 75% to 85% will have a ruptured intracranial aneurysm. Aneurysmal subarachnoid hemorrhage is reported to be responsible for 2% to 5% of all stroke cases. It affects between 21,000 and 33,000 people in the United States per year[1,2] and 5000 patients per year in the United Kingdom.[3] The incidence of aSAH is most commonly quoted as 6 to 9 per 100,000 person-years in most communities.[4–7] It is well recognized that subarachnoid hemorrhage is more common in Finland and Japan, with an incidence of 20 per 100,000 person-years.[5] China reports a 2 per 100,000 annual incidence with South and Central America reporting low incidences.[8] Overall, women are affected 1.6 times more commonly than men[9] and black patients show a 2.1 increased risk over whites.[10,11] In a review of the incidence over the past 45 years, a 0.6% decrease has been noted.[7]

OUTCOME AND ASSOCIATED RISK FACTORS

The natural history of aSAH shows that the mortality rate in the Cooperative Study on Intracranial Aneurysms is 50% at 29 days.[12] The mortality rate has been seen to decrease over the past couple of decades.[13–15] Recent case fatality rates vary from 33% to 45%.[16,17] The exact reasons for this is not clear but may be related to better primary health care, improved blood pressure control, and a decreasing trend in cigarette smoking. There is also a variation in mortality rates among various regions and countries.[13–15] Aneurysmal subarachnoid hemorrhage patients show a 25% mortality rate within 24 hours of the initial hemorrhage, 10% to 15% acute mortality before reaching hospital, and 10% mortality within 24 hours of hospitalization. One-month mortality is estimated at 50% to 60%. Of those who survive, up to two-thirds will have a significantly reduced quality of life with 50% of these patients remaining dependent.[18] Between 25% and 30% of the morbidity and mortality of aSAH is attributed to secondary ischemia, most commonly caused by vasospasm.[19]

The major cause of poor outcome (major morbidity and death) in aSAH patients is related to neurologic injury caused by the hemorrhage itself. This is often determined by the initial hemorrhage and the neurologic sequelae that follow. The direct causes of death and major morbidity as documented by The International Cooperative Study on the Timing of Aneurysm Surgery[20,21] were: (1) cerebral infarction secondary to vasospasm—33.5%, (2) direct effect of hemorrhage—25.5%, (3) rehemorrhage before treatment—17.3%, (4) treatment complications—8.9%, (5) intracerebral hematoma—4.5%, and (6) hydrocephalus—3.0%. The strongest predictors of death and

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poor outcome include an increasing patient age, poor World Federation of Neurological Surgeons (WFNS) grade (decreased level of consciousness) upon initial presentation, and a large volume of blood on initial CT scan.

Grade

Patients with poor WFNS (4–5), Hunt and Hess (4–5), grade do poorly.[22] If no treatment is offered, the mortality rate approaches 100%.[23] Ross and colleagues[24] report on treating poor-grade aSAH patients with late surgery and early coiling. Their data suggest no added benefit by early coiling of poor-grade patients.[24] With active treatment, good outcome has been reported in 50% of Grade 4 patients and 20% of Grade 5 patients.[25] Patients older than 80 years do poorly. Poor-grade patients more often have associated hydrocephalus with an incidence estimated to be 50%.[23] Management of these patients includes placement of an external ventricular drain (EVD) and following 24 hours of observation, 47% of this subgroup will have had made no improvement. In their series,[23] these patients were treated conservatively with a mortality rate of 100% (mean of 2.6 days after presentation). Interestingly, men seem to do worse than woman, with the outcome discrepancy independent of age. Other clinical series[26,27] show some improvement in 40% to 80% of cases following EVD placement.

Global Cerebral Edema

Global cerebral edema, as seen on CT scan, is associated with poorer outcome. Claassen and colleagues[27] found that the admission CT scan showed edema in 6% to 8%[20,27] and that edema developed later in 12%. Global cerebral edema is clinically suggested by an altered level of consciousness and or poor WFNS grade upon presentation. When reviewing mortality at 3 months, the global edema subgroup had a 48% to 50% mortality rate as compared with those without at 18%. Kreiter and colleagues[28] also found poorer cognitive outcome in patients with global brain edema.

Rehemorrhage

The most treatable cause of poor outcome is rehemorrhage.[29] Rehemorrhage poses the greatest threat to life during the initial stages of aSAH and is associated with a mortality rate of 50% to 70%. Rehemorrhage is the highest on day 1 post ictus[30] (4%), then decreasing to 2% per day for the following 4 weeks. After 3 months, the rehemorrhage rate is at 3% per year.[31] In patients managed conservatively, a mortality of 20% to 30% is reported at 30 days.[32,33] Some studies report the incidence of ultra-early bleeding at 15%.[34,35] Ultra-early rehemorrhage occurs within 24 hours of the initial ictus, with most hemorrhages occurring between 0 and 12 hours.[36] Some reports indicate 87% of events occurring within the first 6 hours,[37,38] specifically the first 2 hours.[35] Risk factors for ultra-early bleeding is poorer grade at time of presentation, high initial blood pressure, and extended period between ictus and presentation to hospital.

Rehemorrhage rates for poor-grade patients are higher (20%) than good-grade patients (5%). The rehemorrhage rate in coiled patients was higher but the mortality rate in any rehemorrhaged patient is exceedingly high. Sluzewski and colleagues[39] reported a 1.27% incidence of late rehemorrhage following coiling. Late rehemorrhage had less of an effect on patient outcome than early rehemorrhage. The rehemorrhage events occurred between 8 and 40 months in this review. Factors associated with early rehemorrhage included small aneurysm size and an associated intracerebral hematoma on the initial CT scan. Risk factors for late rehemorrhage include large aneurysm size and incomplete occlusion/obliteration of the aneurysm.

Age

Age affects associated clinical outcomes as well as the initial risk of aSAH. Data from the Framingham study showed an increased incidence in aSAH as the population grows older.[40] The International Cooperative Study of the Timing of Aneurysm Surgery[20,21] found a linear association between advancing age and worse outcome. Aging patients have a higher probability of dying or sustaining permanent neurologic damage or dying from vasospasm than younger patients. The complication rate increased from 28% in the sub-40-year group to 46% in the patients older than 70 years. Discharge glasgow outcome scores at 3 months are worse for older patients. In Lanzino and colleagues'[41] series, patients aged 40 years or younger made a good recovery 73% of the time, with the same degree of recovery found in only 25% of patients aged 70 years or older. Mortality rates are also worse for older patients (35% in the >70-year group) as compared with younger patients (12% in the <40-year group) with the same clinical presentation.

Lanzino and colleagues[41] extensively analyzed the effect of age on aSAH. They found that older patients were more likely to present with a lower level of consciousness, have a poorer WFNS score, have a thicker subarachnoid blood load, and were more likely to have associated intraventricular blood. These patients were more likely to

have hydrocephalus and showed an increased rehemorrhage rate (4.5% in the sub-40-year group to 16.4% in the above 70-year group). The thicker SAH blood load and increased intraventricular hemorrhage is in part explained by the increased subarachnoid spaces and ventricular size secondary to atrophy of the aging brain.

In older patients, increased systolic blood pressure is more common and is associated with a poorer WFNS grade. Advancing age was also associated with increased comorbidities, including hypertension, diabetes, pulmonary dysfunction, cardiac disease, and cerebrovascular disease. Older patients were also found not to have larger aneurysms. Despite having a larger subarachnoid blood load, older patients showed less angiographic vasospasm.[41–44] This might be related to decreasing vascular compliance and a more rigid vascular vessel wall secondary to hypertension and increasing age.

The exact age at which poor outcome seems to be more common is hard to predict. In most studies,[40,41] the relationship between advancing age and poor outcome is a linear one. Statistical series suggests that better outcomes are to be anticipated in patients younger than 60 years of age. The aging brain seems to be less able to cope with the secondary effects of an aSAH. The reasons are a combination of factors,[45–47] ranging from structural changes, biochemical, and reduced plasticity.

Hyperglycemia

Hyperglycemia and its predictive role in outcome has been investigated.[48] It is well known that following aSAH, plasma glucose levels are elevated.[49–51] This may reflect a stress response. Studies have found plasma glucose levels, taken less than 72 hours following the ictus, to be elevated and to correlate with the severity of the bleed and clinical condition of the patient. Juvela and colleagues,[48] testing admission plasma glucose levels, found that hyperglycemia predicted a poor outcome. Lanzino and colleagues[51] suggested that hyperglycemia does not increase the risk for vasospasm (radiographic and/or symptomatic) or cerebral infarction. Finding hyperglycemia (day 3–7 post aSAH) in a patient with vasospasm was associated with a poorer outcome.[51] The harmful effects of hyperglycemia during episodes of cerebral ischemia have also been reported.[49–51]

Medical Complications

Solenski and colleagues[52] reported on the medical complications associated with aSAH and the associated impact on outcome. Their work found that extracranial causes directly contributed to death in 23% of cases, increasing the significance of extracranial causes on par with vasospasm and rehemorrhage as a cause of poor outcome and death. Management of these patients needs a multidisciplinary approach.

Gruber and colleagues[53] reviewed aSAH patient admissions to a neuro critical care unit over a 5-year period. Neurologic failure (Hunt and Hess grades 4 and 5) occurred in 36.8% of patients with an associated mortality rate of 40.4%. Of these patients, 51.7% had isolated neurologic failure and 48.3% showed at least one additional organ system failure. Isolated central nervous system (CNS) failure carried a17.4% mortality but the addition of an extracerebral organ failure increased mortality to 65.1%. Eighty-one percent of patients admitted developed some degree of organ dysfunction, 26% developing organ failure. Single-organ failure was the commonest (16%) followed by two organ system failure (4.9%) and 3 or more system failure in 4.1%. Mortality rates increased from 30.7% (single-system failure) to 91% for two and 100% for 3 or more organ failure.

Le Roux and colleagues[54] found that medical conditions complicated and negatively affected the outcome of subarachnoid patients. Pneumonia and sepsis were common culprits. Close to half (41.8%) of patient deaths, excluding prehospital deaths, are associated some degree of extracranial organ dysfunction. The development of the systemic inflammatory response syndrome (SIRS) heralds a negative turning point in disease progression. SIRS may be the common initiating pathway to patient demise. The detailed pathophysiology of this process is beyond the scope of this article and the reader is referred to the references listed.[55–60] Suffice to say that Gruber and colleagues[53] found 29% of patients admitted to ICU to develop SIRS and 10.3% develop septic shock. The associated mortality rates were 40.3% for SIRS and 80.0% for septic shock against the backdrop of aSAH.

The association of poor outcome and fever has been reviewed. Oliveira-Filho and colleagues[60] found that patients with vasospasm had an increased risk of developing fever. They concluded that the risk of a poor outcome increased with the duration of a fever, independent from vasospasm, disease severity, and infections per se.

Alcohol Consumption

Alcohol consumption has been implicated in the outcome of aSAH. Juvela and colleagues[61–63] reported on this association and found that

patients with a history of heavy alcohol intake were more likely to have a poor outcome. In their series,[62] 12% to 13% of aSAH could be attributed to heavy alcohol intake. Heavy drinking more often preceded episodes of aSAH and most patients who presented following alcohol intake, did so in the ''hung-over'' phase. Patients with heavy alcohol intake were more likely to present in a poorer grade following an ictus and were more likely to die following rehemorrhage or a delayed ischemic event. They were also more prone to additional medical problems. In this regard, a history of heavy alcohol intake probably represents a marker of a specific lifestyle, associated with increased incidence of cigarette smoking, poor nutritional practices with increased body mass index, hypertension, dyslipidemias, and limited physical exercise.

Cocaine

Conway and Tamargo[64] reviewed patients who presented with aSAH following cocaine use. Conflicting reports in the literature[65] initially suggested a worse outcome in this subset of patients.[66,67] Their analysis suggested that there is an increased incidence of vasospasm (63% vs 30% in control group) following aSAH but that outcome is not statistically any different. Consensus has not yet been reached with other authors reporting poorer results.[68] If aSAH was related to cocaine usage, the patient population tended to be younger (average 36 years) and a disproportionate number of anterior circulation aneurysms (97% vs 84% in the control group) were present. Most patients in this subset practiced polypharmacy (81% of cocaine users) and had other comorbid factors associated, including HIV, bacterial infections, and viral hepatitis.

Statins

Statin users were reported to show a better outcome following aSAH.[69] This was attributable to reduced vasospasm and improved cerebral hemodynamics. Parra and colleagues[70] could not demonstrate this benefit. Tseng and colleagues[3] in a follow-up to their initial[69] article indicated benefit by reduced incidence of vasospasm or need to treat vasospasm and improved psychological outcome. The Statins for Aneurysmal Subarachnoid Hemorrhage (STASH) trial, assessing statin therapy on long-term outcome, is ongoing.

Aneurysm Size and Location

Some authors have suggested a larger SAH volume with the rupture of small aneurysms.[71,72] As SAH blood load is associated with vasospasm, this may lead to poorer outcome. Although Taylor and colleagues[72] found smaller aneurysms to produce larger bleeds, outcome was not affected by size. Salary and colleagues[73] found no relationship between aneurysm size and SAH blood load or outcome.

The effect on outcome of location of the aneurysm has been investigated. Kassell and colleagues[20,21] found that patients with aneurysms located on the internal carotid artery or middle cerebral artery had an overall better outcome as compared with patients with lesions of the anterior cerebral artery and/or vertebrobasilar system. Säveland and Brandt[74] concurred with this. Anterior circulation aneurysms tend to fare better than posterior circulation lesions.[75]

Gender

Gender differences do not seem to affect the outcome of aSAH.[76] Females predominate in most series (ruptured and unruptured, clinical or autopsy-based[20,76–82]). Women tend to be older at presentation (51.4 years vs 47.3 years for males) and more often have multiple aneurysms (32.4% vs 17.6% for males). In children and adolescents, males predominate. The sex ratio remains 1:1 up to the third decade and then gradually changes to a female predominance. Female patients tended to have more aneurysms on the internal carotid artery (36.8% vs 18.0% in males), whereas men had more on the anterior cerebral artery system (46.1% vs 26.6% in females).[76] Vasospasm was encountered equally in both sexes.

WFNS Grades 1 and 2

Predicting outcome in patients with a good WFNS grade (Grades 1 and 2) is more complicated. Historically, Grade 1 patients made a good outcome 72% of the time and Grade 2 in 52% (3-month outcome).[23,83,84] When applying the National Institutes of Health Stroke Scale (NIHSS)[84] to admission clinical findings, different outcome data are obtained. The NIHSS allows for a more detailed neurologic assessment. When evaluating the various aspects of the NIHSS, four clinical aspects are found to have statistical significance. These include (1) worst motor (arm) score, (2) dysphasia, (3) visual field deficits, and (4) level of consciousness. The presence of a positive sign (any one of the four clinical aspects) would imply a poorer outcome. Patients classified as WFNS

Grade 1 with positive findings of the NIHSS showed a good outcome in 48% (vs 72%). The same was found for Grade 2 WFNS with positive NIHSS findings with good outcome found in 41% (vs 52%). The addition of these additional clinical factors thus improves the predictive value, but the practically of this has been doubted by some.

Biomarkers

Various biochemical markers have been tested to try to predict outcome following aSAH. No biomarker has yet been shown to provide a prediction method with enough sensitivity and specificity to accurately estimate clinical outcomes. Some of these tested methods have shown promise. These methods include serum S-100 plasma protein levels[85] (associated and indicative of brain damage following SAH), plasma endothelin levels[86] (associated with vasospasm and delayed cerebral ischemia), free fatty acid concentration in cerebrospinal fluid[87] (may play a role in evolution of and hence prediction of vasospasm), and genetic markers such as apolipoprotein E genotype.[88] Genetic testing may aid in the future outcome prediction of patients with aSAH.

OUTCOME AND RECOVERY

Patients who have had an aSAH tend to show higher unemployment rates than controls. They showed more emotional distress and reduced social independence up to 5 years following the event.[89] This outcome is more commonly found in patients who require inpatient rehabilitation.[90,91] Higher than normal rates of mood disturbance, anxiety, depression, and neglect of social contact were found in some patients who had made a good neurologic recovery.[92,93] Researchers found a decrease in general well-being with patients having difficulties with interpersonal relationships, low energy levels, and a feeling of being unwell. Ogden and colleagues[94] reported that 1 year following the ictus up to 59% of patients with good outcomes were still not back to their pre-event employment, and 86% experienced ongoing fatigue. Patients also suffered from lack of motivation, loss of drive, and emotional strain. Investigation showed that patients who suffered an aSAH tended to have experienced a more stressful year before the event. These events may explain, in part, the reduced quality of life experienced by some despite a good neurologic outcome. Another explanation for this phenomenon was that of an organic brain syndrome. McKenna and colleagues[95] did a prospective comparison between patients who suffered an aSAH and those who had a myocardial infarction. They found that about half of each group had a decreased sense of well-being/reduced quality-of-life experience. This may reflect a posttraumatic stress disorder.[95] Powell and colleagues[89] reviewed patients who made a good neurologic recovery. Some 60% showed features of clinical significant posttraumatic stress symptoms at 3 months and 30% at 9 months following the ictus. They were also more prone to increased mood disturbance, dependence, and decreased social functioning. Mood status of patients at 9 months after the event was related to physical and mental health status before the ictus.

Often, the neuropsychological outcome of patients is measured in isolation. The disease impact on the partners and family members is immense.[96] A large proportion of carers found the discharge phase more stressful than the initial acute event. Hop and colleagues[97] showed that partners of patients discharged with a Rankin Score (RS) of 0, were unaffected as compared with the general population. Emotional problems were more common though. The main areas of change in quality of life for family members/partners of patients with RS of 1 to 5, was in ''emotional behavior,'' ''social interactions,'' ''work,'' and ''recreation and pastime.'' Interestingly, the partners sometimes showed a larger degree of reduction than the patients themselves. This report clearly shows the huge impact of aSAH on the lives of patients and their partners.

Pritchard and colleagues[98] found 54% of patients felt depressed following discharge and 33% experienced increased anxiety. Up to 19% of patients attended medical services because of psychosocial reasons. Half of the carers felt that they were negatively affected and 40% felt they were able to cope better with the acute event than when the patient was at home post discharge. Up to 33% reported financial issues and a quarter needed to medicate themselves for stress and anxiety. Mezue and colleagues[99] reviewed the impact of caretaking on family members. They found that 53.8% felt social and personal (emotional) stress with close to half (46.4%) being completely overwhelmed. Their study showed that patients who have a poor outcome induce more stress to the caretaker. Most of the carers are not trained to cope with the various aspects of taking care of a chronically ill patient. This in itself induces huge amounts of stress and anxiety.

THE COST OF CARE

The economic impact of an aneurysmal subarachnoid hemorrhage is devastating. This is true for

both the patient and the health care system. The cost implications to any disease process can be either direct or indirect. Not only is there a direct dollar value to a specific illness or pathologic process, but the chronic care cost is often concealed in various forms, including that of rehabilitation, ongoing medical care, medication and follow-up investigations, and long-term and possible repeated surgical procedures because of complications. Components of indirect cost, among others, include the fiscal amounts related to the loss of income of the patient and the ripple effect this has on the community at large. These amounts (dollar value) and costs (socioeconomic) are harder to calculate or predict.

Direct cost can be attributed to acute and chronic care. Acute care costs include the ambulance transport, emergency room, diagnostic and treatment (medication, surgical, and endovascular) cost, staff cost, facility cost, and initial in-hospital rehabilitation cost. Chronic care cost entails the financial aspects of a rehabilitation facility or chronic care or nursing home. For patients who are sent home for outpatient rehabilitation, the costs include those for home visitation, physiotherapy, occupational therapy, and speech therapy.

Long-term cost depends largely on the survival duration and the degree of disability. Affected patients who are young will incur greater cost than those who are elderly, as the life expectancy is longer. This is also true for patients with greater degrees of impairment. Young patients with a minor degree of disability may not add greatly to the dollar value of chronic care costs, but the decrease in actual earning power will, at least on a fiscal basis, be cumulative over the years. The social impact (neuropsychological cost) of the latter group will be higher than those who are significantly cognitively obtunded.

Indirect costs are influenced by the educational status, work status, number of dependents, and location of the patient and secondary complications that occurred during the primary event may contribute. The degree of impact largely depends on the degree of residual disability. Patients with a high level of dependency will incur higher costs. Certain cost factors cannot be calculated. The loss of the ability to work may be calculated by actuarial manner but the emotional cost to the patient and immediate family is far greater than what can be calculated in fiscal terms.

Hospitalization

When reviewing treatment costs in the initial stages (first 12 months), most of the cost is made up of hospitalization. This creates a large window of opportunity as any treatment or intervention that would shorten hospital, and specifically ICU, stay, will have a huge beneficial cost impact. Ross and colleagues[100] found that 85% of the cost during the first year was made up of hospital admission and radiological and treatment costs. Of this amount, two thirds is devoted to hospitalization and the rest to imaging and therapeutic costs. This latter group is subdivided with 45% of cost going to radiological studies, with angiography consuming 52% of this budget. From the rest of the radiological/treatment budget, 42% is consumed by surgery or coiling. Medications only comprised 3% of the treatment budget.

Regardless of what mode of treatment is used to secure an aneurysm, the presence of complications will increase costs. The development of vasospasm will not only incur costs in extending the duration of ICU stay, hospital stay, and treatment costs per se, with the potential poor outcome escalating rehabilitation and chronic care costs. The same could be said for any complication.

The adoption of newer treatment strategies has also brought along increased cost. The pharmaceutical industry invests heavily into research and development and hence has to recoup their investment via product costs. The evolution of endovascular treatment systems has shown this clearly. The initial introduction of coils has been compounded by the addition of newer types of coils, balloons, and now, stents. All these products are aimed at achieving a better outcome, but this implies increased cost. There are also specific associated complications with these newer devices, this in itself escalating the cost in the acute phase.

As one would expect, the cost of the whole experience will differ from country to country and continent to continent. Costs, although high, seem to be more contained within a national health system/state-funded system than a private sector system.

Coiling Versus Clipping

Direct cost comparison of surgical clipping versus coiling has been done by various authors, each proclaiming their method is better or just as cost effective as that or their competitor. Proponents of endovascular coiling state that their method is less invasive with better outcome at 1 year. Bairstow and colleagues[101] indicated that although endovascular treatment was associated with higher upfront costs, specifically related to consumables (coils, balloons, and stents), the shorter hospital stay associated with better outcome and a sooner

return to work period made this treatment option cost equal to neurosurgical clipping of aneurysms. Follow-up costs and specifically imaging costs are higher in the endovascular group. Retreatment costs are also higher as incomplete coiling will necessitate repeat treatment. Wolstenholme and colleagues[102] found that the endovascular-treated group had a lower cost of treatment when compared with the surgical-clipping group for the acute event and follow-up to 1 year. However, by 2 years, repeated imaging studies, more frequent follow-up, and repeat endovascular treatments eroded this financial advantage and a close to equal costing between the two treatment methods remained. Other studies have also come to similar conclusions.[100,101,103,104]

Javadpour and colleagues[103] did a cost analysis of patients treated for aSAH, in the largest cohort of North American contributor to International Subarachnoid Aneurysm Trial (ISAT).[72] They found no difference in hospital stay between the two groups and also concurred with other authors about the increased imaging cost in the endovascular group. The total cost between the two groups was once again similar. Assessing return to work, the ISAT data were reviewed. More patients in the endovascular treatment group had returned to work by 12-month follow-up. This advantage was not present by the 24-month follow-up. When reviewing total cost following discharge, close to 60% of costs were related to transportation and rehabilitation. Reviews from developing countries indicate a wide array of cost differences. Some of these countries do not have access to regular neurosurgical services, let alone endovascular facilities. Yentur and colleagues[105] from Turkey reported a beneficial cost outcome in the surgical clipping group. They related this to the increased cost associated with importing endovascular consumables. These products are not manufactured locally, resulting in an exaggerated expense in importing products. This translates into increased cost to the endovascular group that is not regained by the reported shorter hospital stay.

Community Impact

When reviewing the community economic impact of aSAH, Pritchard and colleagues[98] reported that 11% of patients lost their employment following the management of a ruptured aneurysm. In excess of 50% were off work for 6 months and 22% off more than 1 year. Family members and caretakers of patients involved in looking after them post event were also heavily affected. Eighty six percent were off work at least 2 weeks with 15% off a quarter of the year (17 weeks) or more. They attributed this to inadequate medical support to the patient, necessitating them to be involved. The lost or diminished productivity is significant.

Screening for New Aneurysms

In patients with a history of a previous treated aneurysm, screening for new aneurysms has been found not to be cost effective, despite an increased risk of a repeat event. The risk of new aneurysm formation and rupture is higher than in the general population. The risk of repeat aSAH following successful surgical clipping is 3% in 10 years.[106] This is more than 20 times the risk in the general population.[106,107] The case fatality rate seen in rehemorrhage following a previous aSAH is 40%.[108] Wermer and colleagues,[108] as part of the Aneurysm Screening after Treatment for Ruptured Aneurysms (ASTRA) study group, reviewed this topic in detail. They documented a 16% incidence of newly diagnosed aneurysms in patients with a previously surgically clipped aneurysm. Of these, 81.4% were aneurysms at new locations and 18.6% were at the previous clip site. Upon reviewing the old imaging, 68% of the ''new lesions'' were actually present (retrospective diagnosis) previously and only 32% were ''de novo'' lesions. Of patients with a known second aneurysm that was treated, enlargement of the second lesion took place in 25%. Treatment was offered to 23% of patients and the others were followed. In reviewing the data, they concluded that screening of these patients was not cost effective.

Clinical Grade

In assessing factors that may predict cost outcome following aSAH, Elliot and colleagues[109] found that clinical grade at time of presentation best predicts not only the length of stay but also the predicted total hospital cost involved. Wiebers and colleagues[110] postulated that the treatment of ruptured aneurysms is 150% more expensive than treating unruptured aneurysms.

Regionalization of Cerebrovascular Services

Regionalization of cerebrovascular services has shown to improve outcome.[16] Solomon and colleagues[111] found that units that do more than 30 surgical clippings per year have a 43% reduced mortality compared with lower case-load units. This was echoed by Berman and colleagues[112] and Luft and colleagues.[113] The health facility's availability to provide endovascular services improves outcome as well. From a neurosurgical perspective, cost evaluation brings into discussion the issue of neurosurgical subspecialization.[114] It

is well recognized that if a specific practitioner devotes a larger percentage of time to a specific disease process, his or her proficiency in treating this disorder increases (“practice-makes-perfect”). This will have a cost-saving effect on the whole.

Bardach and colleagues[115] found that an increased patient load did lead to a better patient outcome when comparing low-volume (<20 cases per year) to high-volume (>20 cases per year) treatment facilities. The improved outcome was also associated with an increased cost but better outcome. When the treating facility was treating more than 50 cases per year, costs were reduced and the outcome was improved. Transfer of sick patients is a difficult situation. Not only does the risk of adverse outcome increase during transport, but the costs associated with this specific case increases. Bardach and colleagues[115] did however find this transfer cost effective, more so if the accepting facility offered endovascular coiling services. Of note is that high-volume centers tend to treat patients more rapidly. This time gain eliminates the time lost in the transfer process. The presence of neurosurgical residents was associated with increased cost of treatment.[112] Berman and colleagues[112] found that treatment volume impacted more so on the outcome of surgical outcomes than the outcome of endovascular coiling.

SUMMARY

Despite the huge advances made in neurosurgical management of aSAH over recent decades, there has not been a proportional improvement in outcome of this condition. Although more people may survive, our ability to impact on the primary pathology has been minimal. It remains a high-cost investment (both fiscal and medical) disease with poor return for the efforts of the treating multidisciplinary team.

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