Economics of epilepsy surgery

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Abstract

Objective: Surgical decision-making is a complex process. First, a medical decision is made to determine if surgery is necessary. Second, another medical decision is made to determine the type of surgery. Third, a corporate decision is made if such a surgery is financially feasible. Finally, a legal decision is made to proceed or refuse the chosen surgery. This paper examines these issues in the case of surgery for medically intractable epilepsy and proposes a method of decision analysis to guide epilepsy surgery. **Materials and Methods:** A stochastic game of imperfect information using techniques of game theory and decision analysis is introduced as an analytical tool for surgical decision-making. **Results:** Surgery for appropriately chosen patients suffering from medically intractable epilepsy may not only be feasible, but may be the best medical option and the best financial option for the patient, families, society and the healthcare system. Such a situation would then make it legally or ethically difficult to reject or postpone surgery for these patients.**Conclusions:** A process to collect data to quantify the parameters used in the decision analysis is hereby proposed.

Key Words

Decision-analysis, economics, epilepsy, game theory, surgery

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Introduction

Surgical decision-making is a complex process. The parties involved are usually the surgeon, the patient, the families, society, insurance companies and the hospital administration. What are the *possible* outcomes of such situations when multiple parties are interacting in self-interest? What are the "optimal" outcomes? What are the economically "efficient" outcomes? What are the medically "efficacious" outcomes? These questions need a systematic review of such interactions. The current standard of medical decision-making is the use of evidence-based analysis.[1] This is a good start but it is insufficient because it ignores the presence of multiple players and lack of full information. Decision analysis[2] understands the presence of uncertainties and the temporal sequence of medical decisions. But it is insufficient because it ignores the presence of strategic actions by the parties involved. The Theory of games[3] is designed to answer such questions. It combines evidence-based analysis, uncertainties, temporal sequencing and strategic interactions among multiple parties to arrive at outcomes where the aforementioned issues of "possible", "optimal", "efficient", and "efficacious" can be addressed.

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Early surgery for epilepsy is medically beneficial to patients who are surgical candidates. Yet the average time from diagnosis to surgery for intractable epilepsy is 20 years in most countries.[2]

Why is this the case?

Medical decision-making is usually approached as evidence-based decision. This is admittedly not altogether correct. Such a process ignores the presence and impact of uncertainties and the presence of several stakeholders. In the end, medically sound outcomes may not be seen in practice. Most medical decisions have a social, financial, familial, or administrative component to it. The outcome of medical decision-making is best described by strategic game theory.[3,4] Each party is working in an environment of incomplete information and uncertainty. Outcomes in such situations are called equilibria of games.[5] In many games, there are multiple equilibria and the game theoretic literature describes ways to narrow the set of equilibria to render better predictions of game outcomes.[5,6]

Consider each stakeholder. The surgeon deals with medical issues in the presence of statistical evidence for a procedure or drug. He can assign probabilities for the various outcomes of

treatment. These probabilities typically lie strictly between 0 and 1 including neither 0 nor 1. Next, the patient is also often uncertain about what they want and what the impact of surgery would be on their life. It would depend on individual families, social setting, and socio-economic considerations. Only the patient would know the quality of life they experience. Next, society ascribes a value to the productivity and welfare of the individual. Its concern is to ensure that outcomes of medical or surgical interventions are Pareto optimal.[7] The hospital administration and the insurance industry are also looking at a world of uncertain possibilities with ethical corporate missions and self-interest. They have to make a decision whether to permit and promote the surgery. The outcome, which is whether the surgery is performed or not, is the result of the complex interaction of all these factors and stakeholders.

Medical literature may have ample evidence that a particular surgical intervention is beneficial to the patient. Such evidence is necessary. Yet that evidence alone may not be sufficient to enable the surgical procedure to take place. Again, consider epilepsy surgery: The surgeon has to have evidence that the surgery would benefit a particular patient.[8,9] The patient will consent only if he has a reasonable idea of the distribution of possible outcome-driven quality of life. Society will lobby for the procedure or drug if the welfare of the patient can result in increased social welfare and aim for Pareto optimal outcomes. Finally, the hospital will agree to fund and promote such a surgery only if it has evidence of overall financial or social benefit. Each of the stakeholders and decision-makers in the above discussion is referred to as a player in a strategic game.

There are analytical tools available to assess such situations and arrive at optimal decisions. One such tool is stochastic game theory with multiple players who make decisions under uncertainty and incomplete information. The outcome of such games prescribes a course of action for each player.[3,5,6] This raises two questions:

1. Do these games have outcomes that will result in chosen actions that will benefit each of the players?
2. Are the players aware of these optimal actions and are they taking these actions at present?

The broader question is whether such games would have a stable equilibrium that guides health care decisions to minimize healthcare costs and maximize social welfare. In order to understand this process better, consider each player and his thoughts when faced with a decision.

Physician

The decision of the physician for surgical or medical intervention is based on knowledge of basic science, together with evidence for the medical benefit of the intervention over its medical costs. Physicians usually practice evidence-based medicine.

In budgeting for healthcare costs, the practice of evidence-based medicine alone should not be viewed as a touchstone for medical and surgical interventions. It is common for patients to reject evidence-proven treatments. For example, nearly half of the patients with stage III colon cancer in the U.S. do not undertake chemotherapy following initial treatment.[11,12] It is also normal for evidence proven surgical intervention not being available to meet the demand. This is the case of epilepsy surgery.

The market for medical services and drugs, functions under incomplete information. There is uncertainty about the medical value of a drug or procedure and drug/equipment testing or case reports of procedures provide the rationale for initial use and pricing under uncertainty. In such markets, risk-averse consumers are willing to pay a premium in exchange for less uncertainty. When level-1 evidence is presented for the medical efficacy of a drug or procedure, the medical uncertainty is grossly reduced. In a market with asymmetric information, this will inevitably raise the market price and hence the cost of caring for the patient.[13,14]

Left alone at this stage, the close nexus between healthcare costs and the practice of evidence-based medicine is obvious and is a natural consequence of markets with imperfect information. Should healthcare be practiced at all costs? This is not only an ethical, legal, and moral question, but is also a practical question that may ultimately help curtail healthcare costs. If medical evidence is viewed as a necessary condition of drug or procedure use when medical, economic and social impacts constitute sufficient conditions, then some procedures or drugs may be rejected even though they may be medically correct. This would bring down market cost of the drug and eventually the cost of healthcare.

Nevertheless, the tool used by the literature and by physicians for surgical or medical intervention is evidence-based practice. Today there is ample evidence that, in appropriately selected patients, epilepsy surgery helps reduce seizure frequency and improve quality of life.[8-10] Hence, as far as the physician is concerned, epilepsy surgery should be considered early in the course of patient management for epilepsy; however, in practice, it is not.

Patient

Patients and families worry about the economic and social impact of the illness, the possible and probable outcomes of intervention and the quality of life before and after intervention. A healthy patient, results in happy families, increased productivity, and increased GDP. There are various ways of measuring the burden of a disease.[15] Disability Adjusted Life Years (DALY) is a measure of the number of healthy life years that are lost due to morbidity or disability from a particular disease. Such a measure although useful in some diseases, is often fraught with controversial assessment of the value of a healthy life relative to a life of illness. Another method of evaluating what a life is worth to a patient, is by estimating the Value of Statistical Life (VSL).[16,17] This calculates one's willingness to pay to avoid a probability of death. For example, if an oilrig worker were told that the risk of death is 1/10000 and he is willing to undertake that risk for an additional $500 increase in pay, his VSL would be 5,000,000. In addition, there may be a social stigma associated with the presence of a disease in a family and removal of such stigma may play a significant role in many societies.[18] Among other variables, the patient is concerned about the burden of disease, VSL and social stigma.

Society

The value of an individual's productivity to society may exceed the actual productive output of the individual due to social multiplier effects and Okun's law.[19,20] Furthermore, this value may change with time due to social, scientific and technological evolution. One way to measure this, would be to quantify the impact of an individual on GDP. This is a challenge and the present value of future contributions need to be assessed and calculated accurately because of changes in the worker (for example learning curves, training and education), changes in society (for example technological and social evolution) and the changing impact of the individual on society.

From 1963 to 2010, life expectancy in the U.S. has increased from 67 to 78 years.[21] During the same time, the ratio of socially dependent workers to that of independent workers in the population has increased from 15 to 20.[22] The GDP per capita has increased from about $3,000 to $45,000.[23] Hence, during this interval, people have been living longer and have become more productive thereby increasing GDP and national prosperity. This means that the relative contribution to GDP by an individual in 1963 is much less than the contribution by the same person in 2010. The same individual producing the same output is worth more to society today than he was 47 years ago. One has to account for this increase in the future value of an individual. Among other variables, society is concerned about the impact of the individual on GDP over a period of time.

Hospital and Insurance Industry

The decisions of the hospital and the insurance industry are often governed by their budget constraints, medicolegal experiences and by their corporate mission. The cost of surgical care now has to be weighed against the discounted present value of future cost of medical care. Social welfare and lost productivity are often not in their optimization problem and may be considered externalities.[24] Such externalities cause socio-economic inefficiencies and can be reduced with the supply of information to the players.[25] Surgery would then be supported by this industry based not only on medical evidence but by the result of a constrained optimization problem. It is important for the practice of evidence-based medicine to agree with the goals of social welfare optimization and healthcare industry optimization goals.

Magnitude of the Problem

Considerable work has been done in describing and computing the costs of epilepsy.[26,27] Prevalence of epilepsy in India is about 10 million patients with an annual incidence of about one million. There are about 2.5 million surgical candidates. Costs of the disease include two broad components: Direct costs and indirect costs. Direct costs include medical consultations, laboratory services, hospitalization costs, and cost of travel to see a physician. Indirect costs include the costs of loss of productivity due to seizures, adverse effects of drugs andthe visits to a physician. In 2001, the estimated annual direct costs in India were about Rupees 4,000 per patient and the annual indirect costs were about Rupees 10,000.[28] These costs add up and the annual economic burden of epilepsy in India was estimated in 2001 to be about 88% of GNP per capita.[28] In the U.S.A., the direct and indirect costs were approximately the same amounts in U.S. dollars.[27] In Europe, the estimated overall costs were about 84 billion euros per year, which results in the magic number of 14,000 euros per patient annually.[29,30]

Thus, the benefits of epilepsy treatment would be the savings of these direct and indirect costs. In addition, society would reap benefits of having a multiplier effect of individual productivity on social welfare. Even if the prevalence and incidence remain the same over time, and even if the real (inflation adjusted) direct costs of medical and surgical management remain the same over time, the total (direct + indirect) costs and benefits of treating epilepsy will keep rising because of improving health indices and life expectancies.

Consider the decision-making that has taken place for glioblastomamultiforme (GBM). The current data of incidence of GBM is about 9,000 per year in the U.S.[31] Death per year from GBM is about 8,000. The patients' ages are typically in the range of 45-70. In Nova Scotia, the estimated direct costs are about $17,000 and the indirect costs are about $15,000.[32] Thus, comparing epilepsy with GBM, incidence of GBM is lower, prevalence is lower, direct treatment costs are higher, indirect treatment costs are higher, benefits are lower, contribution to GDP is lower — yet why do we invest more readily in GBM treatment than in epilepsy surgery?

Modeling the game

Thus the decision for surgery versus medical management can now be modeled as a game of imperfect information with the five players: Physician, patient, society, hospital and insurance industry. We therefore need to collect data on at least the following: From physicians — possible outcomes and meta data on probabilities of those outcomes of epilepsy surgery and medical management of epilepsy; from patients — data to compute burden of disease, VSL, value of social stigma; from society — impact of individual on GDP over time; from hospitals and insurance industry — budget constraints, value of information. Various states of outcomes are associated with various probabilities. A player's choice of a particular action will be done with knowledge of this probability distribution over outcomes. The expected value of taking a particular action is the summation of the product of the probabilities and the respective outcomes. Each player faces a constrained expected value maximization problem under uncertainty and imperfect information. The optimal solution to such a problem would be the set of subgame perfect Nash equilibria of this game.[6] It will be then easy to compare these equilibria to Pareto efficient solutions.

Conclusions

There is medical evidence that surgery is better than medical management for properly chosen epilepsy patients. If the game theoretic decision analysis also points to the same conclusion, then surgery would indeed be the correct option for the early management of epilepsy in appropriately chosen candidates.

Epilepsy has a devastating burden on individuals, families, society, nations and the world. In response, this paper proposes a multicenter, multi-country collection of data on epilepsy that would populate the game theoretic decision analysis required to answer the question: Should we invest more in early surgical treatment of epilepsy?

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