USERS' GUIDE TO THE SURGICAL LITERATURE

How to use an article about prognosis

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Classically, prognosis is defined as a forecast or prediction. Medically, prognosis may be defined as the prospect of recovering from injury or disease, or a prediction or forecast of the course and outcome of a medical condition. As such, prognosis may vary according to injury, disease, age, sex, race and treatment.

The prognosis is a key element, not only in deciding on appropriate treatment, but also in discussing the opinions of patients or relatives concerning management. If the prognosis for improvement or saving a life is very poor, a patient or the relatives may opt to forego surgery. This is especially true if the improvement in life expectancy is minimal despite undergoing a risky, painful procedure. In some disorders it is generally agreed that some patients will benefit from a given surgical procedure whereas others may not. There may be a number of patients in the so-called grey area with different characteristics and stages of disease for whom it is not immediately apparent if the procedure will be appropriate. An in-depth determination of the prognosis can be undertaken, especially if the patient's condition does not require urgent care. The prognosis of the potential outcome may help determine whether the patient falls into the surgery-amenable group or not. The prognosis will determine what the surgeon recommends and what the patient or relatives accept. A poor prognosis may also accelerate the need for a will or other arrangements. It is also important to prognosticate the functional outcome for a patient who survives the disorder, with or without surgery. The prognosis may suggest a near-normal recovery for the patient or a severe functional disability. The prognosis may dictate the need for rehabilitation or even for a change in the occupation or lifestyle of a patient.

In past decades, the accuracy of the prognosis depended on the experience of the prognosticator. More recently, methods that enable even inexperienced but informed clinicians to determine prognosis using the literature and statistical means with considerable accuracy have been developed. It may be beyond the scope of the average clinician to carry out the detailed analysis that we have undertaken herein discussing patients with very complicated head injuries; for such an analysis, a knowledge of statistics is necessary. An ideal team to prognosticate would combine an experienced physician and a person with a knowledge of statistics who surveys the literature. Unfortunately, someone with expertise in a particular problem may not be available in an urgent situation, nor may a person with a working knowledge of statistics. Many of the younger clinicians carry complicated personal digital assistants with them, which may enable them to compute statistics on the spot. Furthermore, computers on which to peruse the literature are readily available in most hospitals. Senior clinicians should ensure that software that allows the required statistical analyses is available. Nevertheless, following the principles we have outlined, average clinicians undertaking a literature review should be able to dramatically improve the accuracy of their prognoses. Even the most seasoned clinicians will improve the accuracy of their prognoses for a given situation using this type of evidence-based medicine.

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Prognosis also plays a major role in informed consent for surgery. Informed consent includes a discussion of the diagnosis; the potential outcome of the disorder; the recommended treatment, including surgery; and alternative forms of management. An experienced surgeon may be able to approximate a prognosis based on the memory or statistics of previous patients. A good knowledge of the literature can improve the accuracy of the prognosis. The chances of improvement, failure and complications should be included in the discussion to obtain informed consent. In rare cases, treatment using a risky surgical procedure may have only a slightly better chance of improving the patient's condition than watchful waiting. The patient or relatives may then decide on conservative treatment if the prognosis indicates little difference in the potential outcome. On the other hand, patients may face a high risk of death from a disorder. After the surgeon's experience or a literature review indicates that the prognosis for improvement with surgery far exceeds that of watchful waiting or conservative treatment, then surgery is offered and usually undertaken despite the risk.

A determination of the prognosis is important in any type of surgical intervention. In the present paper, we used a head injury scenario involving 3 patients. The prognostic instruments we used are specific to this clinical problem. The papers we analyzed dealt with this type of injury, and we used them as our tool. We reviewed the papers to find the components of interest, but we did not evaluate all of the components themselves. However, the principles illustrate a method of prognostication applicable to surgical cases in general.

Sometimes the characteristics or findings in a particular patient may help to determine more accurately the eventual outcome. For example, among patients with acute subdural hematoma (ASDH), a patient with a marked midline shift of the brain, as determined on a radiograph, has a worse prognosis than a patient with a minimal midline shift since the first patient has more pressure on the brain, probably from a more severe injury or more swelling. Such characteristics are called prognostic factors. They can be demographic (e.g., age or sex), disease-specific (e.g., stage of the disease), comorbid (i.e., there are other problems or conditions that coexist with the disease or injury in question) or postincident (i.e., related to the measurement of specific factors within the patient).

One needs to distinguish between risk factors and prognostic factors. Risk factors are those associated with a cause for the disease or injury (e.g., driving a race car in the case of head injury). Prognostic factors are those that affect the clinical condition after it has developed (e.g., the Glasgow Coma Scale [GCS][1] and the radiological findings in patients with ASDH).

Well-designed clinical studies can enable one to learn more about the prognosis of a medical condition. However, ethical considerations often preclude the randomization of patients to evaluate a prognostic factor. For example, it is, of course, not feasible to randomly assign patients with surgically resectable brain tumours into different tumour grades. Instead, to study tumour grade as a prognostic factor, an appropriate method is to prospectively study cohorts of patients with different tumour grades for a sufficiently long follow-up period. This type of study design is called a prospective cohort study. A cohort is a group of people who share a common characteristic within a defined period; in this example, the groups are people with certain tumour grades followed from the time the grade was diagnosed. In well-designed cohort studies, the participants satisfy strict inclusion criteria and the investigators follow a rigorous data collection protocol, including clear definitions of study variables and use of valid and precise measurement of the variables.

Another study design, the case–control study, can be used to assess associations between prognostic factors and outcomes. Outcomes that take a long time to develop or that are rare can render cohort studies unfeasible; for example, in a tumour prognosis study the tumour may be too uncommon or the necessary period of follow-up too long for a cohort study to be possible. The case–control study is an alternative design based on the identification of cases (i.e., participants who have the target outcome) and the selection of controls (i.e., persons without the outcome of interest), allowing researchers to evaluate the relative frequency of prognostic factors among both groups of participants. For example, one might identify and compare patients with tumours who survived 10 years with those who did not survive in terms of the frequency of certain tumour grades. Overall, case–control studies are more susceptible than cohort studies to biases that can lead to invalid conclusions. The reason is that in well-designed cohort studies, the collection of data on the factors under study and on other factors that can affect the outcome of interest (e.g., medical morbidity) can be carried out carefully. On the other hand, in case–control studies, researchers need to gather data on events that have already occurred. This may require a dependence on the recall of patients; their recall is often imprecise and biased because the effort or preoccupation in recalling prior circumstances may be influenced by whether the person is a case or a control. Data collection may also depend on the completeness and adequacy of medical records (e.g., the accurate recording of tumour grades).

We structured the present article in the same format as those in the SOURCE Evidence-Based Surgery (EBS) article series:[2–6] a clinical scenario, literature search and discussion of users' guides for prognosis (Box 1). The purpose of our article was to outline how to locate the best evidence in the current literature on prognosis, how to evaluate the validity of the methodology and results, and how to apply this knowledge to patient care (Box 1).

CLINICAL SCENARIO

Three patients injured in a high-speed 2-car collision that occurred at 8 am were brought to the hospital emergency department. During icy road conditions, a 44-year-old man driving a compact car travelling at high speed entered a curve on a highway. His car slid, crossed the median and struck a full-sized car travelling slowly in the opposite direction. The compact car then crashed against a large tree. The full-sized car, driven by a 40-year-old woman with her 15-year-old son in the front passenger seat, spun around, slid sideways and stopped abruptly, hitting trees along the side of the highway. Paramedics later said the driver of the compact car was not wearing a seat belt and smelled of alcohol. The woman and her son wore both lap and shoulder seat belts.

At the scene, the 44-year-old man was unconscious and had a lacerated forehead and unequal and nonreactive pupils. There was no verbal response or eye opening, and there was bilateral extension of extremities to pain; he had a GCS score of 4.[7] Subsequent investigations showed right rib fractures, a severe flail chest (Abbreviated Injury Scale [AIS] 4),[8] a complex rupture of the spleen (AIS 5), moderate hypoxia, hypotension and a high blood-alcohol level. When he arrived in the emergency department 2 hours after the collision, his condition was unchanged. A computed tomography (CT) scan obtained 2.5 hours after the collision showed a right-sided ASDH 20 mm thick with a 17-mm midline brain shift toward the left, multiple brain contusions and subarachnoid blood involving both cerebral hemispheres (AIS 5). These combined AIS scores gave the man an Injury Severity Score (ISS) of 66.[9] Meanwhile, the patient's wife arrived. She intimated that he had been drinking heavily before the collision. When she asked about his condition, she was told that he had a severe head and brain injury and that he was comatose. She was asked to return after further diagnostic tests.

The woman and her son also arrived at the emergency department about 2 hours after the collision. The paramedics said that half an hour after the collision the woman would open her eyes on command but was confused and that she withdrew her extremities upon painful stimuli; she had a GCS score of 11. When she arrived in the emergency department, her GCS score was unchanged. She had a bruise on the left side of her forehead (AIS 1). Her right pupil was slightly larger than the left, but both reacted to light. Her blood pressure was slightly elevated, but there was no hypoxia. A CT scan showed an ASDH 9 mm thick over the right cerebral hemisphere with a 4-mm midline shift of brain structures toward the left (AIS 4). The CT scan revealed no other abnormalities. There was no other external injury. Her ISS was 16.

The 15-year-old boy had also been rendered briefly unconscious after the collision. Paramedics said that at the scene, he opened his eyes to verbal command and, although confused, he obeyed commands; he had a GCS score of 13. Just under 3 hours after the collision, his pupils were equal and reactive to light. His blood pressure was slightly elevated, but he was not hypoxic. He opened his eyes spontaneously, so his GCS score had increased to 14. The radiologist was uncertain whether or not the CT scan showed a very thin layer of subdural blood over the right cerebral hemisphere (AIS 1). The CT scan showed no other abnormalities. A mild head injury was diagnosed. There was no other external bodily injury. It was likely that he would survive and improve neurologically. His ISS was 1.

The woman's husband was told that his son had sustained a mild concussion and that he was improving and would likely be able to go home soon, but it was not possible at this time to say to what extent the collision would affect his future. He was told that his wife had sustained a head injury of moderate severity, that there was a blood clot over the right side of her brain without any visible damage to the brain itself and that sometimes such blood clots absorb spontaneously. However, if the clot enlarged to become life-threatening, it might require surgical removal. Her CT scan would be repeated later in the day and an update on her condition would be available in 8 hours.

The 44-year-old man was pronounced dead 8 hours after the collision. The teenager continued to improve and was released to the custody of his father 10 hours after the collision. Unfortunately, the 40-year-old woman's GCS score had deteriorated to 10. A repeat CT scan 12 hours after the collision showed that the ASDH had increased to 11 mm in thickness, causing the midline brain shift to increase from 4 mm to 6 mm. There was a single brain contusion measuring 3 mm in diameter at the tip of the right temporal lobe. The neurosurgery service concluded that a craniotomy was indicated for hematoma removal.

Box 1. Users' guide to the surgical literature: how to use an article on prognosis

Are the results of the study valid?

Primary guides

- Was there a representative sample of patients?
- Were the patients homogeneous with respect to their prognostic risk? i.e., Were patients at a similar point in the course of the disease?
- If subgroups with different prognoses are identified
  - Did researchers provide estimates for all clinically relevant subgroups?
  - Was there adjustment for important prognostic factors?

Secondary guides

- Was follow-up sufficiently long and complete?
- Were objective and unbiased outcome criteria used?

What are the results?

- How likely are the outcomes to occur over time?
- How precise are the estimates of likelihood?

Will the results help me in caring for my patient?

- Were the study patients and their management similar to your own?
- Are these results useful in assisting you with managing your patient?

After informed consent, a 3-hour craniotomy was performed with removal of the extensive subdural hematoma from over the right cerebral hemisphere. In the intensive care unit the following day, her GCS score had improved to 12. The neurosurgeon told her husband that her chances were moderate both for survival and also for neurologic improvement.

In the above scenarios it behooves the clinician to be able to approximate the chances not only of survival, but also for clinical improvement. In cases in which the prognosis indicates a vegetative state for outcome or death, regardless of treatment, aggressive management may not be indicated. Furthermore, the relatives, guardians or people giving consent for various forms of treatment need a reasonable estimate of prognosis to determine whether they will consent to a modality of treatment. Relatives and friends who have an idea of the most likely outcome can be better prepared for that outcome.

Literature search

Based on the clinical scenario, to determine the most specific and up-to-date information about survival and functional outcome following brain injury we searched PubMed (www.ncbi.nlm.nih.gov/PubMed) using keywords from our clinical question (refer to the *Users' guide to the surgical literature: how to perform a literature search*[10] for detailed information on how to develop a clinical question and conduct a successful literature research and to Birch and colleauges[11] and McKibbon and colleagues[12] for information on self-audit and practice appraisals for surgeons/physicians). A general search term such as "brain injury" yielded a search with 36 599 hits, an unmanageable number. We used the search terms "predicting survival" and "prognosis" and "brain injury" or "acute subdural hematoma," which yielded 165 articles. To further restrict the search we used the "Limits" function in PubMed specifying that only articles in "English," carried out on "human subjects" of "ages 19–44 years" and published in the 10 years between 1995 and 2005 be selected. The results of this search yielded 53 articles. After scanning through the titles, we found no systematic reviews, but 7 of the articles[13–19] appeared promising. A review of the abstracts for these 7 articles revealed that 3 original studies, one by Signorini and colleagues[13] focusing on predicting survival following brain injury and 2 others by Dent and colleagues[14] and Servadei and colleagues[15] focusing on functional outcome following brain injury, appeared to be particularly relevant to the clinical scenario, and we retrieved these for review.

The users' guide

Having found articles that address the issues of the patients in the clinical scenario, we turned to consideration of the validity of the methods and application of the results to their circumstances. Box 1 displays a short set of questions that are important when interpreting and using prognostic studies.

We applied the questions in Box 1 to the studies by Dent and colleagues[14] and Servadei and colleagues.[15] We used the paper by Signorini and colleagues[13] only as an illustration of prognostic modelling and how this can be applied to the clinical scenario (we assessed the validity of the paper and found it to be adequate).

Are the results of the study valid?

Primary guides

Was there a representative sample of patients, and were the patients homogeneous with respect to their prognostic risk (i.e., were patients at a similar point in the course of the disease)? To study prognosis, the ideal would be to study the entire population with a particular disease, beginning at the same point in the course of disease and throughout the entire course of illness. Obviously it is not feasible to study the entire population; therefore, a representative sample of patients with the given disorder must be studied.

When reviewing articles from the literature, we must determine how the study participants were chosen, at what point in the course of disease they were when they entered the study and whether the sample reflects accurately the spectrum of disease in the entire population. The study population should also be similar to that seen in practice so that the results from the study can be generalized.

Authors should clearly define the patients in their samples: what inclusion/exclusion criteria were used, how the disease or condition was diagnosed and demographic and disease-specific factors such as disease severity (e.g., GCS score, ISS, comorbidities, age). Ideally, all patients should enter the study at about the same point in the course of disease (e.g., within 1 month of diagnosis of stage I or II breast cancer). The time point does not need to be early in the course of the disease, as long as it is consistent for the cohort studied. For example, if some patients in a study of lymph node–positive breast cancer are actually node-negative, the likelihood of poor outcome may be underestimated. Such a sample would be unrepresentative of those with node-positive breast cancer. Similarly, prognostic studies carried out in tertiary settings can yield results that differ from studies conducted in primary care settings. For example, several studies of patients with hypertrophic cardiomyopathy reported annual mortality rates of 2%–6%, but these patients had relatively severe symptoms and were predominantly referrals to tertiary care centres, whereas more recent studies in the community setting reflect a more benign course of disease.[20]

A review of the articles by Dent and colleagues[14] and Servadei and colleagues[15] revealed that they were both retrospective cohort studies with patients seen at a trauma

centre. The authors provided a detailed description of the patients in their samples, including age, results from neurologic exams, GCS scores, type of treatment on admission, CT findings and management (operative v. nonoperative). Dent and colleagues[14] indicated that they wanted "the widest possible spectrum of patients with head injury" with a GCS score of 3–15. They did not exclude patients because of extracranial injuries or severity of intracranial injuries. Servadei and colleagues[15] also included patients with a GCS score of 3–15 but excluded patients with an ASDH smaller than 5 mm. They also provided more in-depth descriptions of their patients' CT scan results as this was of primary interest in their study. Samples from both studies appeared representative of the spectrum of disease seen in patients with ASDH. The patients in the clinical scenario described earlier had similar clinical characteristics as those in these studies, so we were reasonably confident that the data would be applicable to the clinical scenario.

If subgroups with different prognoses were identified in the literature search, did researchers provide estimates for all clinically relevant subgroups, and was there adjustment for important prognostic factors? When they include subgroups of patients with different prognoses, many studies of prognosis use adjusted analyses such as stratified analyses to provide estimates for all clinically relevant subgroups. This type of analysis involves dividing the study cohort into subgroups based on factors that might influence patient outcomes such as demographic characteristics, disease variables and functional status. Outcomes are then evaluated separately for each subgroup. If a large number of variables have a major impact on prognosis, more complex analyses such as logistic regression and multiple regression can be used.

We found that patients in our selected articles[14,15] were not all uniform. There was a considerable variation in the severity of head injury on univariate analyses and consequently subgroups were created. Servadei and colleagues[15] divided GCS scores into 3 subgroups and Dent and colleagues[14] divided them into 2 subgroups. Dent and colleagues found that patients with GCS scores between 3 and 8 had a mortality rate of 47% and 25% of patients had a functional outcome, whereas patients with GCS scores greater than 8 had a mortality rate of 7% and 79% had a functional outcome. The authors defined a Glasgow Outcome Scale [GOS] functional or favourable outcome as a return to normal independent life with or without some disability, whereas they defined a nonfunctional or unfavourable outcome as severe disability, persistent vegetative state or death. Mortality for the whole group was 26%, whereas functional outcome was 55%. These overall estimates are not valid when considering individual patients from this cohort, as they either overestimate or underestimate outcomes depending on an individual's GCS score. Servadei and colleagues[10] found similar results: 67% of patients with GCS scores of 3–8 had nonfavourable outcomes (i.e., death, persistent vegetative state or severe disability), whereas only about 30% of those with GCS scores greater than 8 had nonfavourable outcomes; 54% of the entire cohort had nonfavourable outcomes. Servadei and colleagues also conducted a stratified analysis on findings from their CT scan evaluations and found that increasing hematoma thickness indicated worse outcome, as did increasing midline shift.[15]

Since treatments can also affect patient outcomes, they should be taken into account. In addition, investigators must consider how different prognostic factors affect one another. For example, Dent and colleages[14] divided patients into operative and nonoperative management groups and provided prognostic factors for each group. Before surgery, patients in the operative management group had substantially lower GCS scores and higher rates of large hematoma and midline shift than those in the nonoperative management group, whereas no differences in ISS or age were found between the groups. The authors further subdivided the operative management group into patients who had early surgery and those who had late surgery, and prognostic factors were addressed in each subgroup. It is interesting that patients who had early surgery did not do as well as those who had late surgery. The authors explained that patients who had early surgery probably had more severe injuries than those who had late surgery, illustrating that one must also consider how different prognostic factors affect one another. They further analyzed this association by specifically examining patients who were in a coma and those with a large ASDH and found mortality rates of 30% among patients who had early surgery and 59% among patients who had late surgery. When several prognostic factors may affect one another, adjusted analyses should be used. To determine which prognostic factors are the most powerful predictors of outcome, univariate and multiple logistic regression analyses are used. This topic will be further discussed later in this paper.

Secondary guides

Was follow-up sufficiently long and complete, and were objective and unbiased outcome criteria used? In the study by Dent and colleagues,[14] follow-up included evaluation of the outpatient clinic notes, visits to the emergency department, readmissions or telephone calls to the last known telephone number. Two outcome groups were formed based on the 5-point GOS at last follow-up: functional (i.e., normal functioning, functioning with some disability) and nonfunctional (i.e., requiring assistance, vegetative, deceased). The mean duration of follow-up was 253 days for survivors. Results were reported for all 211 patients identified at the outset; 26% had died.

In the study by Servadei and colleagues,[15] follow-up entailed evaluation of outpatient clinic notes and any readmissions to hospital. Information was not available

from these sources for 11 patients, but they all had a follow-up visit about 6 months after injury. They assessed outcome at a minimum of 6 months after injury according to the GOS using the same criteria as Dent and colleagues.[14] All 206 participants were accounted for; 46% had died.

The duration of follow-up in the studies by Dent and colleagues[14] and Servadei and colleagues[15] seemed to be adequately informative to help determine the prognoses of the patients in our clinical scenario. In the study by Servadei and colleagues,[15] follow-up was at least 6 months, and in that by Dent and colleagues[14] the mean duration of follow-up was longer than 8 months, suggesting that some patients might have had a duration of follow-up that was considerably shorter. Overall, however, we judged the follow-up periods in these studies to be sufficient, and we noted the complete follow-up of all patients in both studies as a strength. The authors gave no information about the reliability or validity of the GOS; however, we noted that the points on the scale were well defined: normal functioning, functioning with some disability, requiring assistance, vegetative and deceased. The misclassification of patients on the GOS was unlikely, especially in the categorization of functional versus nonfunctional status.

What are the results?

How likely are the outcomes to occur over time? The goal of a study of prognosis is to predict which person will have an outcome of interest (e.g., mortality or favourable functional outcome after head injury) and which person will not. Regression techniques are used to assess these types of questions. When constructing regression equations, one or several predictor variables (e.g., GCS score, age) and a target or dependent variables (e.g., GOS score, mortality) are defined. A regression equation assumes a linear fit with possible interactions between the predictor variable(s) and dependent variable and specifies the point at which the straight line meets the Y axis (the intercept) and the steepness of the line (slope of best-fit regression line).[21] The results from the regression equation tell us which variables are independent predictors of our dependent variable. For example, in the study by Dent and colleagues,[14] a logistic regression was fitted to the favourable functional outcome data (GOS scores) and the following predictors or factors: GCS score, age, pupillary status and ISS. Although the paper did not report the logistic regression coefficients, it reported $p < 0.001$ for each variable and the model was additive in the logistic scale. Since an additive model means that probabilities for joint events can be derived from the product of the simple probabilities, favourable functional outcome can be predicted from the raw data rates. As a result, the raw data from the Servadei article[15] (Table 1) can be used to estimate the favourable functional outcome proportions that can in turn be used to predict favourable functional outcomes in future patients.

Table 1. Favourable functional outcome probabilities*

Variable	Favourable functional outcome probability
GCS score	
3–8	0.31
9–12	0.62
13–15	0.77
Age, yr	
0–20	0.70
21–30	0.63
31–50	0.48
> 50	0.38
Pupillary status	
Reaction	0.66
No reaction	0.19
Fixed	0.04
ISS	
12–15	0.95
15–25	0.80
25–50	0.40
50–75	0.20

GCS = Glasgow Coma Scale[1]; ISS = Injury Severity Score.[9]
*Data drawn from Servadei et al.[15] Two of us (F.B., R.H.) provided estimates for ISS based on clinical experience.

For each patient in the clinical scenario, we can now compute the favourable functional outcome probabilities by translating their current clinical status into categories in Box 1 and computing the product of the 4 important variables' probabilities to get the chance of favourable functional outcome (Table 2). For the 44-year-old man, the chance of a favourable functional outcome is less than 1%; the chance is about 16% for the 40-year-old woman and about 34% for her 15-year-old son.

Signorini and colleagues[13] used multivariable logistic regression to derive a model to predict the 1-year survival rate in patients with traumatic brain injuries. They found that 5 variables, including age, GCS score, ISS, pupillary reaction and evidence of hematoma on CT scan, were predictors of 1-year survival and validated their prediction rule in a cohort of 520 patients. They then developed a nomogram (Fig. 1) to predict the probability of survival at

Table 2. Computing favourable functional outcome probabilities for patients in the clinical scenario

Patient	GCS score	Age, yr	Pupillary status	ISS	Favourable functional outcome
Man	0.31	0.48	0.04	0.20	0.001
Woman	0.62	0.48	0.66	0.80	0.157
Boy	0.77	0.70	0.66	0.95	0.338

GCS = Glasgow Coma Scale[1]; ISS = Injury Severity Score.[9]

1 year. For each of the 5 variables, the corresponding number of points is read from the top scale. These are then summed to give a total points score, which is then readily translated into a probability of survival on the bottom scale (nonlinear).[13] We can apply the data from the 3 patients in the clinical scenario to the nomogram by Signorini and colleagues to calculate their probability of 1-year survival (Table 3).

How precise are the estimates of likelihood? The papers do not give any direct measures of precision; however, we can treat each of these rates as if they are binomial variables and construct exact 95% confidence intervals (CIs) for each of these estimates. Also, we can use the sample size of the study by Servadei and colleagues[15] (n = 206) for this computation. If these proportions are multiplied by the sample size, we get an expected number of cases and from this expected number and the sample size we can estimate the exact 95% CIs using Minitab, version 14. These results are produced in Table 3.

We would now be able to give feedback to the families of each patient in the clinical scenario using the nomogram (Fig. 1) from Signorini and colleagues[13] and information in Table 2, Table 3 and Table 4 as follows: the 44-year-old man had a predicted 1-year survival of about 5%, with a less than 2% chance of a favourable functional outcome; indeed he died. The 40-year-old woman had about a 16% chance of a favourable functional outcome (likely between 11% and 22% or about 1 in 6) with a 1-year survival probability of 99.5%. The 15-year-old boy had a predicted 1-year

Table 3. One-year survival computations for patients in the clinical scenario based on the nomogram by Signorini and colleagues[13]

Variable	Patient; value (no. points)*		
	Man	Woman	Boy
Age, yr	45 (100)	40 (100)	15 (100)
GCS score	4 (5)	11 (45)	13 (55)
ISS	66 (16)	16 (90)	1 (100)
Pupillary status	UR (0)	Both RA (30)	Both RA (30)
CT scan	HT (0)	No HT (25)	No HT (25)
Total points	121	290	310
Probability of 1-year survival	0.05	0.995	0.997

CT = computed tomography; GCS = Glasgow Coma Scale;[1] HT = hematoma; ISS = Injury Severity Score;[9] RA = reactive; UR = unreactive.
*Unless otherwise indicated.

Table 4. Confidence intervals of favourable functional outcome for patients in the clinical scenario

Patient	Favourable functional outcome	Expected cases	95% CI
Man	0.001	0	0.000–0.018
Woman	0.157	33	0.113–0.218
Boy	0.338	70	0.275–0.409

CI = confidence interval.

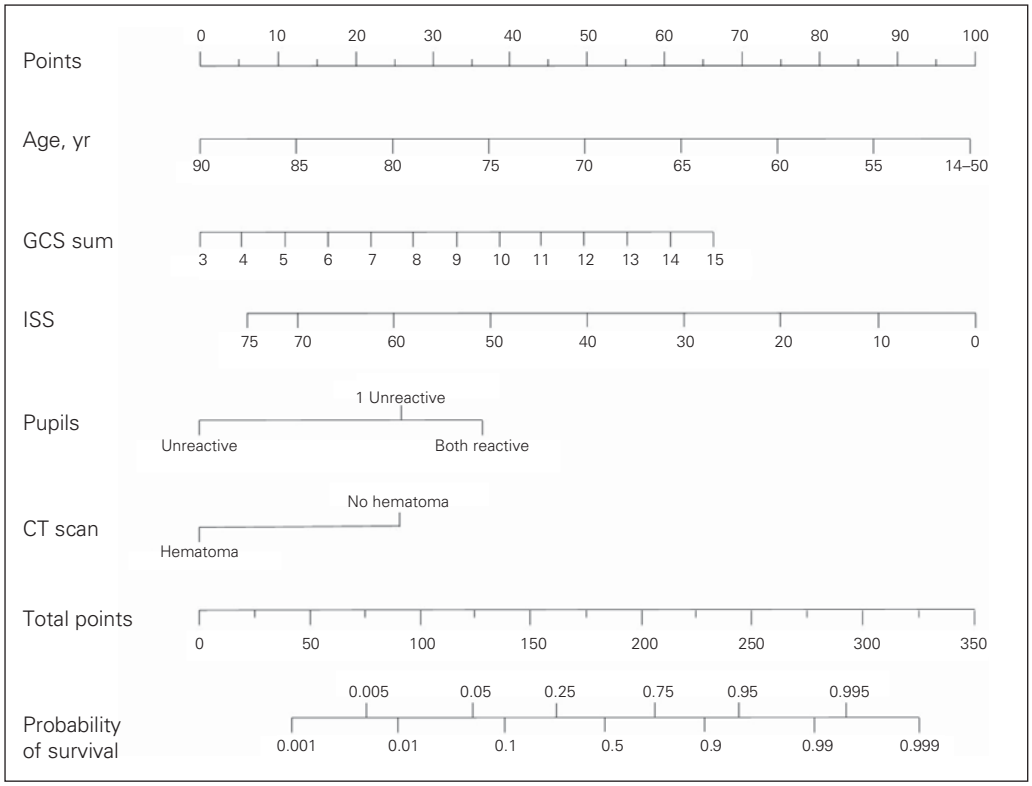

Fig. 1. Nomogram for predicted probability of survival at 1 year. Reproduced from Signorini DF, Andrews PJD, Jones PA, et al. Predicting survival using simple clinical variables: a case study in traumatic breast injury. *J Neurol Neurosurg Psychiatry* 1999;66:23[13] with permission from BMJ Publishing Group Ltd.

survival of 99.7% with about a 35% (between 28% and 41% or about 1 in 3) probability of having a favourable functional outcome. The mother and son were discharged from hospital. They were not seen again in the follow-up timeframe of the study, so any residual long-term deficits are unknown.

Will the results help me in caring for my patient(s)?

Were the study patients and their management similar to your own? Many of the patients in the studies selected from the literature had similar problems to those in the clinical scenario.

Are these results useful in assisting you with managing your patient? The patients described in the selected studies are ones that are commonly seen in a busy hospital emergency department, where the clinician must often make rapid informed decisions. The prognosis for survival gives an indication of how aggressive physicians should be in the treatment modalities. It also allows the treating physicians to triage the patients who are best treated early. Being able to convey the chances of survival and reasonable functional outcome to the patients' relatives or guardians also helps them to make better informed decisions. In addition, knowing the chances for a favourable functional outcome can help formulate plans for rehabilitation and future planning for the relatives. From an academic perspective, it can also help generate hypotheses about the biological mechanisms leading to poor outcomes.

The 44-year-old man was given an AIS of 5 (critical) for his brain injuries since they were considered to be critical and would probably lead to his death a few hours later, with or without extraordinary intervention. The 40-year-old woman was assigned an AIS of 4 (serious) for her brain injury since it was less severe and might have required later intervention but was not immediately life-threatening.

Discussion

The AIS is not really an injury scale, but allows allocation of the severity of a particular injury for threat to life. The scale varies from 1 to 6, with a 6 being incompatible with survival. There tends not to be a good correlation between the AIS and the GCS, which are each rated independently. There have been many injury scales reported in the literature since 1970, but the ISS appears to be the most widely used. The AIS scores can be allocated for each of 6 injured body regions. The highest rated injury for each region is used; the scores for the 3 most severely injured body regions are squared and are then summed to produce the ISS.

The GCS in major trauma does not reliably predict the presence of anatomic head injury but is strongly associated with morbidity and mortality.[22] On the other hand, the AIS based on the original CT scan provides useful prognostic information in patients with severe head injuries.[23]

In the study by Servadei and colleagues,[15] each variable was highly significant, and the model was additive in the logistic scale. Therefore we could predict a favourable functional outcome from raw data since an additive model means that probabilities for joint events can be derived from the product of simple probabilities for head injuries.

We feel based on clinical judgement that the prognosis for favourable functional recovery in the 15-year-old boy from the clinical scenario was probably better than the statistics indicated. In the papers we have discussed, the data were derived mostly from patients with moderate to severe head injuries such as those sustained by the 44-year-old man and the 40-year-old woman as opposed to milder injuries sustained by the boy. For example, the patients described in the studies by Dent and colleagues[14] and Servadei and colleagues[15] all had subdural hematomas, and Servadei and colleagues excluded patients with hematomas less than 5 mm. The boy in our clinical scenario did not fit all the criteria for patients in our reference papers as his subsequent studies excluded the presence of an ASDH. This markedly improved the functional prognosis compared with that of patients with such a lesion. Moreover, the boy's ISS was 1, whereas functional patients in the nonoperative group in the study by Dent and colleagues[14] had an average ISS greater than 20.8, worsening the prognosis for functional recovery. Nevertheless we chose to include the boy in our analysis since an ASDH was initially suspected.

Conclusion

Prognosis encompasses many aspects and is also dependent on a number of variables. Clinically it is usually important to determine the chances of survival or the likely type of functional outcome. This article suggests a framework for estimation of prognosis for a condition using trauma patients as an example. The accuracy of the prognosis has in the past been enhanced by the experience of the prognosticator. More recently, the literature and statistics have been used to allow even inexperienced but informed clinicians to arrive at a meaningful prognosis. One should base the prognosis on studies using patients similar to those in question. It is important to select key features in the patient, which, when present in the selected literature may help clarify the probable outcome, including survival and quality of life. Such studies should show the likelihood of a clinical outcome occurring over a period of time. One must also define the accuracy of the estimation of likelihood.

The determination of prognosis will hopefully lead to the selection of the most appropriate form of management. The findings should enable informed discussion of the case with the patient or relatives for reassurance or counselling so that they may make plans for the future.

Competing interests: None declared.

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Le American College of Surgeons, le British Columbia Surgical Society, le Canadian Association of Bariatric Physicians and Surgeons, le Canadian Association of Surgical Chairmen, l'Association canadienne des chirurgiens universitaires, le Canadian Hepato-Pancreato-Biliary Soceity, le Comité canadien de l'éducation chirurgicale de premier cycle, l'Association des chirurgiens James IV, et l'Association canadienne de traumatologie sont au nombre des sociétés qui appuient cette activité.

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