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The Surgeon, Journal of the Royal Colleges of Surgeons of Edinburgh and Ireland

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Predictive models in cancer management: A guide for clinicians

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ARTICLE INFO

Article history:
Received 22 April 2015
Received in revised form
31 January 2016
Accepted 11 June 2016
Available online xxx

Keywords:
Predictive
Tools
Models
Cancer
Management
Survival

ABSTRACT

Background: Predictive tools in cancer management are used to predict different outcomes including survival probability or risk of recurrence. The uptake of these tools by clinicians involved in cancer management has not been as common as other clinical tools, which may be due to the complexity of some of these tools or a lack of understanding of how they can aid decision-making in particular clinical situations.

Aims: The aim of this article is to improve clinicians' knowledge and understanding of predictive tools used in cancer management, including how they are built, how they can be applied to medical practice, and what their limitations may be.

Methods: Literature review was conducted to investigate the role of predictive tools in cancer management.

Results: All predictive models share similar characteristics, but depending on the type of the tool its ability to predict an outcome will differ. Each type has its own pros and cons, and its generalisability will depend on the cohort used to build the tool. These factors will affect the clinician's decision whether to apply the model to their cohort or not.

Conclusions: Before a model is used in clinical practice, it is important to appreciate how the model is constructed, what its use may add over and above traditional decision-making tools, and what problems or limitations may be associated with it. Understanding all the above is an important step for any clinician who wants to decide whether or not use predictive tools in their practice.

Predictive models and clinical medicine

The main aim of predictive modelling is to build tools, which will help to estimate risk or the probability of an outcome occurring.[1] In cancer management the outcomes both clinicians and patients look for include survival (over a specific period such as five or ten years), and curability (risk of recurrence).

Clinicians are trying to involve patients more in decision-making, and patients, with the information they access online, are asking for more control regarding their disease management. Medical professionals have traditionally used their own clinical judgement to facilitate this, however it has

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http://dx.doi.org/10.1016/j.surge.2016.06.002

Please cite this article in press as: Kazem MA, Predictive models in cancer management: A guide for clinicians, The Surgeon (2016), http://dx.doi.org/10.1016/j.surge.2016.06.002

been recognised that the use of clinical judgement alone to estimate specific outcomes is difficult and will suffer from personal bias as clinicians' view points are affected by their previous experiences and knowledge of similar patients.[2,3]

One way to reduce personal bias is by taking a multidisciplinary team (MDT) approach to discussing the management and outcomes of these patients. However it is important to remember that not all team members will be present for every discussion, and still the process will rely on clinical judgement.[4] Building predictive models that aim to predict specific outcomes may help the decision-making process. Some of these tools will give general risks, and others are more individualised. Models to predict survival in breast, prostate, gastric, bladder, and colon cancer have been built over the last few years,[5–10] and clinicians are increasingly using these tools to help patients make informed decisions regarding their treatment options.[11]

Types of predictive models

There are different models that can be used to predict outcomes. These models consist of risk grouping, probability tables, artificial neural networks (ANN), classification and regression tree (CART), and nomograms (Table 1). Although these models look different in the way they handle data and predict outcomes, they can be compared by assessing them against specific qualities, primarily how accurate they are at predicting outcomes, their performance in relation to risk, their generalizability, and how complex the model is.[12]

Risk grouping

In risk grouping the model consists of allocating patients to a specific group depending on their characteristics. This is often applied to cancer patients, to stratify them into low, moderate, or high risk. The aim is to enable the clinician to estimate certain risks and benefits for patients depending upon which group they fit into. Examples of risk grouping used in clinical practice are the D'Amico score for prostate cancer,[13] Children's Oncology Group (COG) risk groups, and International Neruoblastoma Risk Group (INRG) classification.[14]

Risk grouping is an easy way to allocate patients into groups, but predictions are made on the assumption that all patients in the same heterogeneous group are the same, which is not true. This creates risk of bias and can sometimes underestimate or overestimate risk.[12] As well, variables or risk factors are usually given the same weight to predict the outcomes, which may not reflect the actual effect of each variable in producing the outcome.[15] Various studies have demonstrated that other predictive models are superior to risk grouping.[6,16] If risk groups are used clinically to predict an individual patient's outcome, it must be clearly explained to the patient that the risk given may not reflect the patient's own actual risk, but rather represents the overall risk of the group he is allocated to.

Probability tables

Using look-up tables the clinician can predict specific outcomes depending on which group a patient fits into. These tables are usually built by putting different predictors together and then categorising them to give the prediction required. Examples include "Partin Tables",[17] to predict the possibility of prostate cancer spread beyond the gland, and "Lifetime Risk of Developing or Dying from Cancer" table[18] developed by American cancer society to predict these risks in the United States population.

Using these tables may not be as easy as risk grouping, although it may give a more accurate prediction. But still these predictions are still not individualised, and some patients may find the risks given in odd ratios difficult to understand. Furthermore, studies have shown that the predictive accuracy of look-up tables is exceeded by other tools, such as nomograms.[16,19]

Artificial neural networks (ANNs)

Since the early 1990s ANNs have been used to assist clinicians in making diagnoses like myocardial infarction.[20] They have also been used in cancer patients, for example, to predict disease free survival after hepatic resection for hepatocellular carcinoma,[21] and to assist in diagnosing focal pancreatic masses.[22]

ANNs are simply a form of machine intelligence, using the human brain as a model. The network is constructed of multiple layers of interconnecting neurons, which have the ability to analyse, learn, and recognise patterns from data fed into the system. In this way the network will be able to predict a specific outcome when data are fed into it, keeping in mind that it has been trained to predict that outcome e.g. myocardial infarction.[12,23]

Table 1 – Comparison of predictive models (modified from Shahrokh et al.).

Method	Pros	Cons
Risk grouping	Easy to apply in clinical practice Easy to interpret	Heterogeneity within each group
Probability tables	Not difficult to use in clinical practice More accurate predictions than risk grouping	Non individualised prediction Odd ratios difficult to explain to patients
Neural Networks	Better accuracy Can deal with complex inter-variables relations'	Complex statistics Not very easy to apply clinically Black box model
Nomograms	Better accuracy Easy to apply in clinical practice	Complex statistics
CART	Easy to apply in clinical practice White box model	Complex statistics

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