Br. J. clin. Pharmac. (1993), **35**, 581–586

Presenting clinical pharmacology and therapeutics: a problem based approach for choosing and prescribing drugs

THEO P. G. M. DE VRIES
Department of Pharmacology and Clinical Pharmacology, WHO Collaborating Center for Clinical Pharmacology and Drug Policy Science, Faculty of Medicine, University of Groningen, Bloemsingel 1, 9713 BZ Groningen, The Netherlands

As a guide to the rational choice and prescribing of drugs a normative (ideal) problem-solving model has been developed. This model combines medical problem solving and decision analysis, practical medical aspects, and pharmacological facts and basic principles. It consists of a set of actions or steps: determine the goal for treatment, choose a (drug) treatment, start drug treatment, monitor the results, draw conclusions, determine further action, and stop, alter or continue treatment. All steps require several kinds of skills. The cognitive skills needed include the correct use of pharmacological facts and basic principles in the framework of the whole problem-solving process.

Keywords clinical pharmacology drug-prescribing problem-solving model education undergraduate

Introduction

Most of the decisions made by doctors depend on value judgement and logic, a certain way of reasoning (Balla & Edwards, 1986). Experienced doctors are often unaware of this, and their performance may be incomprehensible to students unless it is brought to their attention. It is important to make the basis of judgements and the logic behind them explicit to students, so that basic questions are not stifled and the reasoning is clearly explained. In the context of rational prescribing students should particularly be taught the pharmacological basis of the criteria needed for making a drug choice. To promote the rational choice and prescribing of drugs a problem-solving model was developed in 1982 in the department of Pharmacology and Clinical Pharmacology (Faculty of Medicine) of Groningen. This model combines medical problem solving and decision analysis, practical medical aspects, and pharmacological facts and basic principles. In this paper the model will be described, and a description of the learning objectives which can be derived from it follows.

The model for choosing and prescribing drugs

The model is a so-called normative or prescriptive model that describes how something should be done ideally or logically. Several sources were consulted. The general structure of the model is based on theories of medical problem solving, while the process of choice is largely based on theories of normative decision analysis (Edwards & Newman, 1982; Feinstein, 1967; Kassirer & Gorry, 1978; Sacket *et al.*, 1985; Schwartz & Griffin, 1986; van Rossum, 1977; Vlek, 1987; Weinstein & Fineberg, 1980; Wulff, 1976). Experts in the field of general practice and clinical pharmacology were consulted to refine the general structure, and to develop the specific sub-steps of the model.

The ideal process of medical problem solving can be described in general terms, i.e. steps or phases, similar to those used to solve scientific problems (Table 1). The assumption is that medical judgement and performance can be improved by implementing similar procedures, which involve identifying a problem (the question); generating one or more hypotheses; collecting and processing reliable and valid data (the experiment); interpreting the results; drawing conclusions; and recommending further action.

Viewed thus the medical problem-solving process is in fact a small 'experiment' that starts when a patient seeks medical care. The doctor tries to find an explanation for the patient's problem, preferably a clear diagnosis. To solve the patient's problem the doctor has to choose from several possible treatments. If the patient is prescribed a drug he or she should comply (in the experiment) by taking the drug correctly. Measurement of the response by the doctor, usually during a subsequent visit, will reveal the results of the drug treatment. On the basis of this assessment a conclusion can be drawn as to whether the patient's problem has been solved or not. If not, further action is needed and the whole process starts again.

This process should be regarded as a sequential problem-solving activity, i.e. judgments and decisions are occurring all the time. For example one can distinguish 'diagnostic', 'therapeutic' and 'monitoring' problem-solving elements within the whole process; more detail can then be built into the basic steps of the general model as described above. The sub-steps of the 'therapeutic'

Table 1 Normative model of scientific, medical and therapeutic problem solving

(Scientific)	*MEDICAL/therapeutic (1–7)*	
(question)	PATIENT'S PROBLEM	
(hypothesis)	DIAGNOSIS	
		1. determine the goal of treatment 2. choose a (drug) treatment 2.1 take/choose a first-choice (drug) treatment 2.2 verify appropriateness for the patient
(experiment)	TREATMENT	
		3. start drug-treatment 3.1 write a prescription/administer the drug 3.2 inform, instruct and warn the patient 3.3 make next appointment
(results)	RESULTS	
		4. monitor the results 5. draw conclusions
(conclusions)	CONCLUSIONS	
		6. determine further action
(recommendations)	FURTHER ACTION	
		7. stop/alter/continue treatment

and 'monitoring' process will be described below in a manner in which they can be explained to medical students (see also Table 1). A clear diagnosis and prognosis is the starting point of the whole therapeutic process, and an understanding of the pathophysiology within the framework of the psychological and social circumstances of the patient is also important.

Determine the goal of treatment (therapeutic objective)

Students have to determine the goal of treatment by deriving it logically from the diagnosis and prognosis. The goal should be one or more of the following therapeutic objectives:

1. curing a disease/disorder,
2. relieving a symptom,
3. preventing a disease or pregnancy,
4. combinations of 1, 2 or 3.

In most cases modifications of physiological processes or of the underlying pathophysiology is the direct goal, and this leads to the next step.

Choose a (drug) treatment

Choosing a treatment rationally can be a very difficult task in itself. What is more rational choices in ordinary practice often have to be attained despite incomplete knowledge about the patient concerned, uncertainty about the disorder, pressure of time and other disadvantages. A practical approach to this problem is to divide the decision into two phases:

1. Firstly, the physician has in mind, or to hand, one or two first-choice or standard treatments for each disorder, disease or complaint with which he or she is likely to be confronted.
2. Secondly, when the individual patient presents the doctor determines whether this first-choice treatment is appropriate for the individual case.

This way first-choice treatments are drawn from a personal formulary compiled by a selection process undertaken earlier by each student or doctor, for example during the undergraduate training period or postgraduate education. They are treatments which are *effective, safe, convenient* for most patients with a certain disorder, and which entail the lowest possible *cost*. During daily practice the appropriateness of the first-choice treatment for a particular patient has to be verified, in effect entailing a further check on efficacy, safety, convenience and cost.

Choose a first-choice (drug) treatment The 'first choice' for a particular disorder is not necessarily a drug choice. Students should learn to consider three basic categories of action and combinations of these, any of which may provide one or more possible first choices:

1. treat without drugs,
2. treat with a drug,
3. refer to somebody else for treatment,
4. combinations of 1, 2 or 3.

Normatively a first-choice treatment should be selected analytically, by a certain method or logical-analytical approach. This implies that initially, one or two first choices have to made for each of the categories. After that these choices will be compared, resulting in a first-choice treatment for a particular disorder.

One decision-analytical method will be discussed because of its relative simplicity and therefore its practical usefulness for teaching. It is based on the so-called multi-attribute utility theory or analysis (Edwards & Newman, 1982). As an example the choice between three imaginary drugs will be used to determine a first-choice drug treatment for category 2 above. First choices

Table 2 Multi-attribute utility analysis of the choice between three imaginary drugs (a,b,c), using numeric values (range 0–10) for allocating values to each eligible drug for each criterion

	Criteria (values)				
	Efficacy (0.5)	*Safety (0.3)*	*Convenience (0.1)*	*Low cost (0.1)*	*Total (1.0)*
Drug a	9 (4.5)	7 (2.1)	3 (0.3)	5 (0.5)	7.4
Drug b	5 (2.5)	4 (1.2)	9 (0.9)	8 (0.8)	5.4
Drug c	4 (2.0)	9 (2.7)	6 (0.6)	7 (0.7)	6.0

for the other categories (1 and 3) can be determined in the same way.

Two steps are essential in this analysis:

1. structuring,
2. evaluation.

Structuring involves determining the options (the available drugs), and the criteria necessary for a comparative judgment. Suppose a decision has to be made between three drugs, which have been selected on the basis of their known efficacy in changing the (patho)physiology or reaching a therapeutic objective. These so-called choice options are 'structured' in the left column of a choice scheme (Table 2).

The basic choice criteria are efficacy, safety, convenience and cost (Parish, 1973), and these are placed at the top of the scheme. For each individual drug or group of drugs, these four criteria can be defined further. For example, when choosing an antibiotic drug one criterion of efficacy might be the degree of sensitivity of the organism in question. Criteria for safety will include possible side-effects and interactions.

Information on the four criteria (and the values accorded to them — see below) can be obtained in various ways. For teaching purposes a consensus meeting or discussion among the students may be considered with the guidance of a clinical pharmacologist and use of clinical pharmacology and therapeutics texts and selected literature, for example review articles.

The *evaluation* proceeds in three steps. First one allocates relative weightings to the choice criteria from 0.1–1.0, depending on the relative importance of these criteria in the specific case. For example, in an acute life-threatening situation the convenience, cost and possibly even the safety will weigh less heavily than the criterion of efficacy.

Second one allocates values to each eligible drug for every criterion; in our example that will entail quantifying known differences between the drugs concerning efficacy, safety, convenience and cost. Numeric values can be used here, if they have been derived from the results of clinical trials or epidemiological studies. Failing that relative values can be used; for example plus and minus signs, or ordinal numbers. If for example there are N choice options, the relative values may vary from 1–N. As an illustration some hypothetical numeric values (range 0–10) have been placed in the choice-scheme. However, each of these methods for quantifying differences between drugs has its advantages and disadvantages. For example, ordinal numbering does not allow one to express small differences in values between drugs; on the other hand reliable numeric values are difficult to find. Realizing this is in fact an important educational goal of the whole exercise. It should function as an eye-opener to students, leading them to discover for themselves that 'the' best drug is a relative concept, and to understand why this is so.

The third step in the evaluation process is to calculate the total values of the choice options to determine the 'best' one. For every option the values per criterion are multiplied by the values of the related choice criterion, and then added. The total score for each option can be placed in the fifth column, on the right.

The method can be summarized in the following formula:

$$U_j = \sum_{i=1}^{n} W_i U_{ij}$$

where U_j is the overall score for the jth drug; W_i is the value assigned to the ith criterion; and U_{ij} is the score of the jth drug on the ith criterion. Σ is the sum of the weighted scores over all criteria from the first (1) to the last (n).

This method has been computerized (spreadsheet) in order to obtain results of a consensus meeting quickly and easily. In addendum I a description is presented of an analysis made by fifth year students choosing a first choice drug for treating an acute asthma attack.

In this way one or more first choice drugs can be chosen to treat a certain disease or symptom, including the standard dosage form, dosage schedule and duration of treatment. The first-choice drugs selected form a relatively limited range of drugs (approximately 60 for general practice) which students or physicians have chosen for their own use, and with which they have made themselves familiar. Together with the non-drug treatments selected they have a range of first-choice treatments. These can be used to solve patient problems in daily practice, but this will entail checking the appropriateness of each treatment for a particular patient.

Verifying appropriateness for the individual patient

Verifying the appropriateness of a specific treatment implies a further check on the efficacy, safety and convenience of the treatment concerned. For first-choice drug treatments the most practical approach in daily practice is to check consciously for contraindications, interactions and possible inconvenience. In this context students should develop a sixth sense for being cautious when treating high-risk groups of patients for example: pregnant or breast-feeding women; children; the elderly; and patients with renal or hepatic failure. After that they have to determine clearly for the individual case whether (1) the drug can be prescribed, (2) another drug should be chosen, (3) the dosage form, dosage schedule or duration of the first-choice drug has to be changed, or (4) no drug should be prescribed.

Start treatment

Students must realize that the treatment chosen has to be used correctly if one is to get valid and reliable 'experimental' results, i.e. achieve maximum efficacy, safety and convenience (compliance) at minimum cost. For a drug treatment this means:

- writing a prescription, or administering the drug correctly,

- informing, instructing and warning the patient correctly and in a way the patient can understand,
- taking measures to monitor the drug treatment which has been instituted, for example by making a further appointment if relevant.

Monitor results
Draw conclusions

If a patient comes back he or she presents a follow-up problem, to assess the result of treatment. Students have to assemble the follow-up findings meticulously and check if the therapeutic goal has been reached. Has the treatment solved the patient's problem? This check should be based on the same criteria as are used for choosing the treatment, and must lead to clear conclusions.

Determine further action
Stop/alter/or continue drug treatment

When the outcome has been assessed subsequent actions should be considered by the students. If the problem has been solved the treatment has to be stopped in a safe manner. In the case of a chronic disease continuation of treatment may be needed to maintain the response attained. On the other hand the treatment may need to be stopped or altered to assess the current state of a chronic disease. If the problem has not been solved at all, or only in part, further action will be needed to find the cause of that failure. This requires that the whole process starts again (see Table 1). If the *diagnosis* appears to be incorrect the treatment will probably also have been incorrect and needs to be stopped or altered. The same applies if the *treatment* is incorrect, including instances where the drug has caused a new problem, for example by causing side-effects. If *patient compliance* was not optimal the patient will be instructed correctly again, or the treatment must be stopped or altered.

Learning objectives

All the steps described above require skills; cognitive, motor or communication skills. Cognitive skills are for example required to choose a drug, decide what information or instructions is (or is not) to be given, and to monitor the results of drug treatment. Administering a drug is an example of an essential motor skill. Imparting information and instructions to the pharmacist (prescription) and to the patient are examples of communication skills. Knowledge about drugs and an understanding of basic pharmacological principles are essential for the cognitive skills. The main teaching objective is that students master all the required skills before qualifying as a doctor (see Table 3). A similar list of general objectives has been published recently by the Council for Medical Student Education in Clinical Pharmacology and Therapeutics (Nierenberg, 1990).

Each department or medical faculty has to determine specific objectives in accordance with the local situation, e.g. the specific patient problems students should be able to solve before qualifying as a doctor.

Table 3 Learning objectives for therapeutic teaching

When solving patient problems, the student is able to:

(cognitive skills)

- determine a goal for treatment
- choose no drug treatment
- choose a drug, dosage form, dosage schedule and duration of drug treatment
- choose a combined drug and non-drug treatment
- decide what to tell the patient (information, instructions and warnings)
- decide when and how to monitor drug treatment
- draw conclusions after monitoring
- decide to continue, change or stop drug treatment

(motor skills)

- prepare a drug for parenteral application
- administer a drug parenterally

(communication skills)

- write a prescription
- inform the patient about effect of treatment
- inform the patient about side effects
- instruct the patient (how to use/take drug)
- warn the patient (to avoid dangerous situations)
- make (next) appointment with the patient

Concluding remarks

A systematic approach to choosing and prescribing drugs has advantages and disadvantages. One disadvantage may be that it over-simplifies a highly complex reality. Critics may claim that it simply states the obvious, and that all good doctors work by these methods. They may also assert that experts already provide first-choice drugs for most disorders, for example in formularies or textbooks, and that students need not undertake something that has already been done, and perhaps done better. There are however several good reasons for making a formal commitment to the teaching or problem solving and decision analysis (Balla & Edwards, 1986; de Vries, 1988; Lubsen, 1987).

1. It is important to make the basis of medical judgements and logic explicit to students. In the context of rational prescribing they should in particular be taught the pharmacological basis of the criteria needed to make a drug treatment effective, safe, and convenient. These criteria are not only essential for choosing a first-choice drug, including the assessment of new drugs, but also for choosing drugs in daily practice, i.e. for particular patients, including the search for an alternative drug if the first-choice drug is not appropriate. Students should therefore be trained how to make both types of drug choices. Others have supported similar approaches to choosing first-choice drugs (Janknegt *et al.*, 1991; Mathur *et al.*, 1988).
2. It is important to impress upon students that several factors may induce irrational prescribing in the highly complex reality of daily practice. They need to learn how to deal with these factors. This can be done in two ways. The first is to take such factors as the starting point, and give students advice on how to deal with these, e.g. how to deal with the demanding patient, or with intense pharmaceutical promotion. The second way is to take the student as a starting

point and teach him or her a systematic approach to choosing and prescribing drugs rationally. Armed with this they should know how to treat patients rationally, and also how to handle factors which induce irrational prescribing, for example the demanding patient, or the heavily promoted drug.

Prescribing practice may be improved if the undergraduate period is used to lay a better foundation for a systematic approach to choosing and prescribing drugs. It may *prevent* sub-optimal prescribing behaviour and eventually produce doctors with sound prescribing attitudes, routines, and instincts. Longitudinal research is needed to determine whether these goals can be reached. To this end we developed a course in pharmacotherapeutics based on the model described, and have started to study the effect of this approach on the rational choice of drugs by medical students. The course and the results attained to date are described in the subsequent papers.

I wish to thank all those who have contributed to the Pharmacotherapy project, and Professor Wim Lammers, Professor Graham Dukes, Professor Geert Bremer and Dr Wim Bender for reviewing this paper.

References

Balla, J. I. & Edwards, H. M. (1986). Some problems in teaching clinical decision making. *Med. Educ.*, **20**, 487–491.

de Vries, T. P. G. M. (1988). Het voorschrijven van geneesmiddelen: wat is het probleem en wie beslist. In *Jaarboek Huisartsgeneeskunde*, eds Aulbers, B. J. M. *et al.*, pp. 173–184. Utrecht: Bunge.

Edwards, W. & Newman, J. R. (1982). *Multiattribute evaluation*. Beverly Hills: Sage Public.

Feinstein, A.R. (1967). *Clinical judgement*. Baltimore: Williams & Wilkins Company.

Janknegt, R., Smelik, J. & Steenhoek, A. (1991). Betablokkers: keuzekriteria en produktvoorkeur. *Tijdschr. Ther. Geneesm. en Onderzoek*, **1**, 26–30.

Kassirer, J. P. & Gorry, G. (1978). Clinical problem solving: a behavioral analysis. *Ann. int. Med.*, **89**, 245–255.

Lubsen, J. (1987). Artsen aanzetten tot rationeler beslissen. *Uitleg (Ministerie O&W)*, **3** (89), 52–54.

Mathur, V. S., Chaudhury, R. R. & Fraser, H. S. (1988). A scoring system for selection of essential drugs. *Int. J. clin. Pharmac. Ther. Tox.*, **26**, 122–124.

Nierenberg, D. W. (1990). A core curriculum for medical students in clinical pharmacoogy and therapeutics. *Clin. Pharmac. Ther.*, **48**, 606–610.

Parish, P. A. (1973). Drug prescribing—the concern of all. *Roy. Soc. Health*, **4**, 213–217.

Sacket, D. L., Haynes, R. B. & Tugwell, P. (1985). Deciding on the best therapy. In *Clinical epidemiology; a basic science for clinical medicine*, eds Sacket, D. L., Haynes, R. B. & Tugwell, P. Boston: Little, Brown & Company.

Schwartz, S. & Griffin, T. (1986). *Medical thinking; the psychology of medical judgement and decision making*. New York: Springer.

van Rossum, H. J. M. (1977). *Medisch Onderwijs; wegen zoeken en wegen* (thesis). Groningen: Rijks Universiteit Groningen.

Vlek, C. (1987). Psychologische besliskunde; tussen weddenschapswetenschap en professionele beslissingsondersteuning. *De Psycholoog*, **22**, 73–86.

Weinstein, M. C. & Fineberg, H. V. (1980). *Clinical decision analysis*. Philadelphia: Saunders.

Wulff, H. R. (1976). *Rational diagnosis and treatment*. Oxford: Blackwell Scientific Publications.

(Received 30 June 1992, accepted 25 January 1993)

Addendum I
Multi-attribute utility analysis (example)

During a consensus meeting a group of fifth year medical students has to determine a first-choice drug for treating an acute asthma attack. The group is first divided in subgroups of two or three students. Each sub-group then determines the choice options (the available drugs) and (sub)criteria, and structure these in a choice scheme (see Table 4 below). Information is obtained from pharmacology and therapeutic textbooks, drug compendia and

Table 4

	Criteria (values)				
	Efficacy (0.35)	*Safety (0.28)*	*Convenience (0.28)*	*Low cost (0.09)*	*Total (1.0)*
Antihistamines (promethazine/oral)	1.8 (0.6)	4.9 (1.4)	5.1 (1.4)	5.8 (0.5)	3.9
Corticosteroids (prednisone/oral)	6.0 (2.1)	2.9 (0.8)	2.2 (0.6)	6.0 (0.5)	4.0
β-adrenoceptor agonists (salbutamol/inhalation)	10.0 (3.5)	5.1 (1.4)	6.4 (1.8)	10.0 (0.9)	7.6
Methylxanthines (theophylline/i.v.)	9.1 (3.2)	3.3 (0.9)	3.6 (1.0)	8.2 (0.7)	5.8
Anticholinergic (ipratropium bromide/inhalation)	6.4 (2.2)	4.7 (1.3)	4.0 (1.1)	10.0 (0.9)	5.5

bulletins, and selected review articles. Each sub-group then allocates relative weightings to the choice criteria from 0.1–1.0, depending on the relative importance of these criteria in the specific case. After that each student allocates relative numeric values (range 0–10) to each eligible drug for every criterion. They finally calculate the total values of the choice options to determine the 'best' one as described in the paper.

In order to achieve consensus all the values of the students are placed on a blackboard and subsequently averaged. After that the average total values are calculated. As an example the average values of an analysis made by a group of fifth year students ($n = 9$) are shown below, choosing a first-choice drug for treating an acute asthma attack.

On the basis of these average values a discussion among the students takes place with the guidance of a clinical pharmacologist. Finally, one or more first-choice drugs are chosen, including the standard dosage form, dosage schedule and duration of treatment.