Research on the Pathways for Cultivating Clinical Medication Decision-Making Ability in Veterinary Pharmacology Teaching

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Abstract: *There is a gap in the teaching of veterinary pharmacology between the transmission of declarative knowledge and the formation of clinical drug selection behaviour. Decomposition of the Multi-level Cognitive Structure of Decision-making Ability and Identification of Key Mapping Nodes in Pharmacodynamic and Pharmacokinetic Knowledge Systems: The decomposition method mentioned above can be applied to analyze the multi-level cognitive structure of decision-making ability in this paper. A way has been put forward to organise the content of decision-making ability by combining the classification of drugs according to clinical reasoning, decision-oriented analysis of drug interactions and embedded strategies for species-difference knowledge. The whole circle of interactive assessments will cover all links in the training of reasoning ability, simulation-based scenario teaching and traceable formative evaluation, down to the breakdown of abilities and the design of assessments.*

Keywords: *Teaching of Veterinary Pharmacology, Clinical Drug Selection, Reasoning Training, Restructuring of Teaching Content, Formative Assessment*

Introduction

At present, most of the teaching in veterinary pharmacology is still in a declarative mode; students have had little opportunity to apply what they have learned in complex clinical situations, such as selecting appropriate drugs and determining dosages, and thus there is a structural mismatch between knowledge storage and decision-making application. At the beginning of clinical decision-making for medication, some information needs to be collected, and so on. Deconstruct the cognitive factors of clinical decision-making, restructure the pharmacology teaching content in light of the demands for decision-making, establish an interactive teaching and assessment system, and thus this paper aims to build an ordered path from knowledge structure to decision-making behaviour and offer theoretical support for the reform of veterinary pharmacology teaching.

1. Dimensional Deconstruction of Clinical Medication Decision-Making Ability and its Association with Pharmacology Knowledge

1.1 Cognitive Levels and Core Skill Composition of Clinical Medication Decision-Making

The process of clinical medication decision-making is becoming more cognitive, and it is based on the recognition and memory of drug information; at the intermediate stage is drug selection reasoning according to pathophysiology, and finally, at the highest level, there is dynamic adjustment and risk prediction. Given that there are many differences among animals, they metabolise drugs differently, and other reasons for treatment also vary; thus, these decisions will be different. To reach the next level of thinking, we need to learn why a drug works rather than just memorising the rules. First, one needs to obtain relevant information on the primary drug from animal case studies; then, the advantages and disadvantages of all treatment methods should be weighed; finally, one should foresee any late-onset drug interactions or adverse effects. Another is that people are more likely to believe there are particular reasons for the failure of treatment or harm caused by it. The above skills form a closed-loop system; that is, they will gather data and then modify the plan accordingly.

Based on the above cognitive system, the teaching of veterinary pharmacology should be reformed and its sub-skills made trainable. Knowing how a drug is eliminated is a basic level of knowledge, but

adjusting the time between doses according to changes in a person's liver and kidney function is an advanced decision-making skill. We need to distinguish between "knowing drug properties" and "using properties to solve clinical problems" in teaching. Based on the logical relationship among drug attributes and diseases, students will be motivated to build conditional knowledge graphs; that is to say, given some symptoms of illness, they can find corresponding drug treatments. The above way will reduce the thinking load of the decision-maker and improve the speed of handling difficult cases.

1.2 Mapping Nodes in the Veterinary Pharmacology Knowledge System and Decision-Making Ability

The two basic parts of the knowledge system in veterinary pharmacology are pharmacodynamics and pharmacokinetics; they correspond to the two fundamental problems in decision-making: "which drug should be selected?" and "how to use the chosen drug?". Pharmacodynamic knowledge can provide information on receptor selectivity, efficacy and potency to solve the first problem of screening for drug indications, and pharmacokinetic knowledge can offer parameters for absorption, distribution, metabolism and excretion to determine the specific dose, route and frequency of drug administration. The intersection points of the two kinds of knowledge, such as the relationship among the therapeutic window, half-life and dosing interval, are necessary places for the formation of decision-making ability. Pharmacokinetic parameters in different species are also not the same (e.g., cats are deficient in glucuronidation), so there should be a separate section for each species in the knowledge base.

In order to build a good knowledge system and make reasonable judgments, one needs to know when to use each piece of pharmacological knowledge in practice. For example, the knowledge of enzyme inducers and inhibitors should not be taught in isolation but used to decide on multi-drug combination therapy. Be aware that when a patient is taking phenobarbital and glucocorticoids together, there is competition for the hepatic drug-metabolising enzyme pathway, so adjust the dosage of one or both drugs accordingly. The mapping nodes are also connected to the mapping of renal function indicators, the accumulation risk of aminoglycosides and the effect of the rate of protein binding on drug displacement. Identify and strengthen these nodes in teaching to make the knowledge more vivid and practical for life[1].

1.3 Analysis of Deficiencies in Cultivation of Decision-Making Ability in Current Teaching

The main content of the current teaching in veterinary pharmacology is declarative knowledge, such as the classification of drugs, their mechanisms of action and side effects, but it lacks the procedural and conditional knowledge required for decision-making. Declarative knowledge is the basis of decision-making, but it cannot be used directly for reasoning in clinical practice. A typical deficiency is that although learners can list the mechanism of action of a particular drug, they are unable to spontaneously adjust the dosage according to the circumstances of animals with liver disease or hypoalbuminemia. Assessment of teaching is based on students' ability to remember knowledge and use it in a simple way with a single drug; it does not cover training or evaluation of complex decision-making problems, such as multiple drug interactions, comparison of therapeutic routes and risk stratification.

The second is that pharmacological knowledge is often out of touch with the demand for quick decisions in practice. Many drugs need to be changed at different times during a person's illness, so antibiotic de-escalation therapy and gradual reduction of analgesics are often used. Currently, the teaching materials do not often show the Design of decision-making nodes based on the drug concentration-time curve, and there is also no training in logical derivation of alternative regimens after treatment failure. There are no simulated cases in the teaching materials to help students learn how to make decisions. In particular, the teaching does not cover the legal obligations for medication in food-producing animals, such as the withdrawal period of veterinary drugs, control of antimicrobial resistance, regulations on veterinary prescription drugs and residues, etc.; all of these are necessary for making clinical decisions. As there is no good low-risk environment for practising decision-making, learners will probably have typical decision-making biases in real clinical situations, such as failing to collect all the necessary information, reducing the number of choices, and ignoring feedback. Therefore, we need to reconstruct the teaching links of pharmacological knowledge and decision-making ability.

2. Content Reorganisation of Pharmacology Teaching for the Cultivation of Decision-Making Ability

2.1 Integration of Drug Classification and Mechanisms According to Clinical Reasoning Needs

Traditionally, the organisation of pharmacology teaching has been in a linear manner according to drug classes (e.g., antibiotics, non-steroidal anti-inflammatory drugs, anesthetics). The categories are easy to store, but they do not support retrieval according to clinical reasoning. Clinical drug selection should know which drugs to use based on the patient's disease at a specific time, rather than just grouping the drugs according to the type of disease. Therefore, the restructuring of teaching content should be in line with the demands of clinical reasoning, and drugs are organised into "modules according to therapeutic goals", such as selecting vasoactive drugs for septic shock and creating multimodal analgesic regimens for chronic pain. The modules have drugs with different pharmacological mechanisms and various types of interactions among them, so students can construct a problem-oriented network of pharmacological knowledge.

First, we need to find the connections among all the drug-action paths in the mechanism of action. Inotropes (Pimobendan, Digoxin), vasodilators (ACE inhibitors such as Enalapril), and diuretics (Furosemide) are all different kinds, but they all aim to reduce the three modifiable factors of preload, afterload and myocardial contractility in acute heart failure. Teaching can show the extent of these reasons and help students understand why, after taking a particular drug, the dosage of another drug needs to be changed. Build a mechanistic association diagram and do not teach each drug in isolation; this can help students improve their reasoning efficiency in situations with many drugs and avoid decision-making blind spots caused by scattered knowledge[2].

2.2 Decision-oriented Analysis of Drug Interactions and Adverse Reactions

Teaching the teaching of drug interactions should move away from listing the kinds of interactions (e.g., additive, synergistic, antagonistic) or traditional cases (e.g., warfarin and sulfonamides) and become a decision-making risk assessment system. The degree of drug interaction, the size of the therapeutic index, how susceptible individual animals and conditions are to monitoring, etc., all affect the clinical significance of drug interaction in clinical veterinary medicine. Teaching content should cover how to conduct operational assessment, what kind of interactions need to be known, whether they are clinically significant, how to adjust the dosage or change the drug regimen, and when to monitor. Therefore, the knowledge gained here can be arranged in a series of choices to help people manage multiple medications for their pets more reasonably. Management decisions should also be part of the teaching content for antimicrobial agents; that is to say, drugs need to be selected based on the results of antimicrobial susceptibility tests, exposure to subtherapeutic concentrations should be avoided, and regulations on veterinary prescription drugs must be followed.

Teach the causes of adverse reactions first, and then learn to solve problems. Teach the students the general adverse effects of various drugs (e.g., polyuria and polydipsia induced by glucocorticoids, nephrotoxicity caused by aminoglycosides), and inform them how to react in the event of such adverse reactions, how serious they are, and whether they can be corrected. For example, if the serum creatinine of a sick animal is high after treatment with an angiotensin-converting enzyme inhibitor, we need to determine whether this increase is due to improved blood flow or damage to the kidneys, and then decide whether to continue giving the drug, reduce the dose, or switch to a different kind of medicine. The teaching materials should be in the form of decision trees for adverse drug reactions, and at each branch node, a judgment criterion needs to be set (e.g., a rise of more than 30% in serum creatinine from baseline is considered a reason to stop taking the drug); thus, knowledge of adverse drug reactions can be turned into accurate clinical regulatory skills.

2.3 Knowledge Embedding Strategies for Species Differences in Medication Decision-Making

Differences among species affect the selection of drugs at both the level of pharmacokinetics and pharmacodynamics, and these differences can be of various extents. Glucuronosyltransferase in cats has low activity, so drugs such as acetaminophen and aspirin are eliminated slowly in cats. Dogs have various sensitivities to ivermectin based on the different functions of P-glycoprotein at the blood-brain barrier in different breeds, and the tolerance of the intestinal microbiota in rodents to some antibiotics is much lower than that in carnivores. Do not learn the differences as isolated facts, but rather apply them to the corresponding stages of decision-making. Build a "species-drug-decision" ternary map in the

teaching materials and list the particular contraindications and dose-modification coefficients of common drugs[3].

The strategy of knowledge embedding is to put species-specific information in the trigger conditions of clinical reasoning. Teaching should build a drug-screening logic based on the characteristics of different species, and when animal species are provided in the case information, learners should be able to automatically retrieve the drug-metabolism bottlenecks and known high-risk drug lists for that species. Acetaminophen should not be given to a cat with pain because cats have a glucuronidation deficiency and are thus prone to serious methemoglobinemia; therefore, NSAIDs such as aspirin may be used, but they have a very long half-life in cats and need to be given at extended intervals. Flunixin meglumine is a typical representative of non-steroidal anti-inflammatory drugs that can be used to reduce pain in dogs after surgery, but there is also a risk of stomach upset and kidney damage that needs to be monitored. Differences among species should also be taken into account in the evaluation of the pharmacodynamic end point; for example, the risk of gastrointestinal perforation after administering non-steroidal anti-inflammatory drugs in horses is much higher than in cattle, and this difference will affect the determination of the therapeutic window and monitoring frequency for different species. For food-producing animals, that is to say cattle, pigs and chickens, the use of medicinal products should be based on withdrawal periods and an assessment of the risk of veterinary drug residues in animal products. Marbofloxacin is employed for the treatment of bovine mastitis; therefore, it is necessary to adhere strictly to the recommended milk discard and withdrawal periods. Organised embedding methods can help to organise the problems of remembering many species for decision-making.

3. Instructional Interaction and Assessment Design for Developing Decision-Making Ability

3.1 Pathway for Constructing Stepped Clinical Reasoning Training Modules

The steps of the modules in the clinical reasoning training are based on the idea of gradually increasing cognitive load, and the three stages of the medication decision-making process are: first, information collection and problem identification; second, generation and comparison of treatment plans; finally, dynamic adjustment of the plan and reassessment of risks. All the levels have different patterns for recalling and learning pharmacological knowledge and cognition. First, extract the main variables from the case description of an animal, such as species, body weight, status of hepatic and renal function, concomitant medications, target therapeutic effects, etc., and identify drug-related problems (e.g., incorrect dosage, drug contraindications, drug interactions). The second level requires students to develop at least two practical choices based on the principles of pharmacokinetics and pharmacodynamics, and then compare and rank them according to the three factors of effectiveness, safety and convenience. The third is to change the original plan according to the therapeutic response (e.g., if it is ineffective or if there are side effects) and then adjust the dosage or switch to another drug[4].

Build it this way and re-annotate the pharmacological knowledge points according to the level of decision-making. For example, at the first level, only the knowledge of half-life is needed to know that it is an input for calculating the dosing interval; at the second level, it needs to be used to compare the fluctuation amplitude of peak and trough concentrations under different dosing regimens; and at the third level, it should be employed to determine the time to reach a steady-state concentration and the corrective measures after a missed dose. The progress of the training modules is not determined by how long one has been studying, but rather by whether a certain level of accuracy has been reached in each stage before moving on to the next. Diagnostic feedback in the modules can show why there is an error at all levels of cognition, such as whether the mistake is in recognising the drug's metabolic pathway or applying the dosage formula, and then generate personalised training plans.

3.2 Simulation-Based Scenario Teaching Strategy for Medication Decision-Making Pathways

A simulation-based scenario teaching of medication decision-making pathways is a kind of interactive case tree that illustrates pharmacological knowledge in a non-linear decision graph. Each simulation unit has a case of an animal and creates a few decision nodes to select drugs, set drug doses, choose routes of administration, and decide whether to use combination therapy. After the student selects an item, the corresponding results of that item and any changes in the body's condition at that time (such as blood pressure, serum creatinine, pain level, etc.) will be shown immediately.

Fluctuations in people's drug metabolism and changes in laboratory test results are random variables that are added to the simulation to account for the randomness of real clinical situations. When learners do not know all the facts, they need to be able to choose flexibly and change their original plans according to the new information[5].

The general idea of the teaching method is to show the division-and-combination points in the chain of decisions. Branching points are cases where all reasonable choices can achieve the aim of therapy, and convergence points are situations that need to be reconciled after different initial choices to reach the same management idea in the end. For example, in the treatment simulation of canine bacterial cystitis, learners may choose amoxicillin-clavulanate or enrofloxacin as the first drug; however, because of the different safety profiles of these drugs in animals with hepatic and renal insufficiency, there will be many different branches in the following monitoring frequency. Based on the simulation, a Decision Path Map will be constructed, and at each decision node, the alternative choices, excluded options, and expected results of these options will be added. Therefore, the students will learn not only which option is correct but also how to generate other choices and rule out the wrong ones in the selection process; thus, they can internalize the metacognitive regulation ability of clinical medication reasoning.

3.3 Setting of Traceable Formative Evaluation Indicators for the Decision-Making Process

The indicators of formative assessment should be changed from the traditional pharmacology evaluation of knowledge recall and simple application to quantitative data on the effectiveness of each step in the decision-making process. The three indices of the system are the completeness of information collection, the normativity of reasoning steps and the adaptability of plan adjustment. Completeness of information collection refers to whether all the reasons for a person's choice of medication at that time have been obtained from the patient, such as body weight, age, pregnancy status, indicators of liver and kidney function, allergies, current medications, etc. Normativity of reasoning steps refers to whether a learner chooses to first analyse the elimination path of a drug, then calculate a dosage, check for interactions, rule out contraindications and note any problems in the reasoning process, such as missing steps or incorrect order. Adaptability of plan adjustment is a student's ability to notice problems in time and develop a new plan when the first plan fails or due to other bad luck.

All the indices will be based on the operating record at that time and not the final results. For example, when a learner finally chooses the combination of furosemide and pimobendan for a case of canine heart failure, the evaluation system will record this final choice, as well as whether the learner considered angiotensin-converting enzyme inhibitors, whether the initial dose of furosemide is suitable for the patient's renal function, and whether there are any contraindications to pimobendan, such as aortic stenosis. The evaluation indicators are as follows: If more than two of the key parameters in the results of the information collection are missing, it will be assumed that the foundation for decision-making is insufficient; if the interaction screening step in the reasoning sequence is skipped, the learner will need to return to the training module; and if the set decision window for plan adjustment is exceeded, it will be considered a lack of cognitive flexibility. The above indicators can help the students organise themselves and provide some places for teaching correction.

Conclusion

Three-dimensional Paths for Cultivating the Clinical Medication Decision-Making Ability of Veterinary Pharmacology Students are presented systematically in this paper. First, by dividing the cognitive levels of decision-making ability, this paper shows that there is a gradual connection among drug information recognition, comparative reasoning and dynamic adjustment; it identifies the main mapping nodes in the pharmacodynamic and pharmacokinetic knowledge systems that affect decision-making, points out structural deficiencies in the current teaching of procedural knowledge, conditional knowledge and dynamic decision-making training. Secondly, the three main directions put forward for reorganising the teaching content in this paper are: the integration of drug classification and mechanisms with the requirements of clinical reasoning; decision-oriented analysis of drug interactions and adverse effects; and knowledge embedding strategies for differences in species during medication decisions; that is, static pharmacological knowledge can be turned into dynamic resources that are convenient to be recalled in decision-making situations. Finally, this paper puts forward an interactive and evaluative system for training people's decision-making ability; there are three levels of training in clinical reasoning, simulation-based scenarios to learn how to make medication decisions, and traceable

formative evaluation indicators for the decision-making process, all of which form a complete closed loop from knowledge input to the behaviour of decision-making. The goal of the next study will be to build a standardised decision-making training case library based on real clinical case data, develop an intelligent teaching platform that can automatically observe the decision-making process and provide feedback, explore all kinds of ways to improve decision-making ability in light of the differences among different species and disease models, and conduct validity studies to confirm whether the indicators of decision-making ability are in line with actual performance in clinical medication.

References

[1] Cui Y., et al. "Exploring the Medication Rules of Chinese Veterinary Drugs in Treating Animal Strangury." Chinese Journal of Veterinary Medicine, 60(3)(2024): 114-118.

[2] Chen D.C., et al. "Exploration and Practice of the New Model of 'Micro-video, Flipped Classroom, Traditional Teaching' in Experimental Teaching of Veterinary Clinical Diagnostics." Journal of Domestic Animal Ecology, 45(8)(2024): 92-96.

[3] Liu S.Q., et al. "Exploration and Practice of Safety Management in Animal Experiments in Undergraduate Teaching —Taking Pharmacology Experiments as an Example." Industry and Technology Forum, 23(9)(2024): 259-261.

[4] Liu T.H., and Lu H. "Teaching Reform and Practice of Veterinary Pharmacology under the Background of the 'Double High Plan'." Vocation, (4)(2023): 26-29.

[5] Yin G.W., et al. "Construction and Application of the Online Open Course of Veterinary Clinical Diagnostics." Journal of Domestic Animal Ecology, 43(1)(2022): 92-93.

[6] Zhan Y., et al. "Discussion on Approaches to Improving the Teaching Effectiveness of Veterinary Clinical Diagnostics Course." Heilongjiang Animal Science and Veterinary Medicine, (12)(2020): 155-157.