

Supplementary Material to the manuscript titled: “Common Biases, Difficulties, and Errors in Clinical Reasoning in Veterinary Medical Encounters with a Case Example”

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Table S1. Common difficulties/errors in consideration of client ± patient situation during veterinary clinical encounters and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical cognition	Any of the others	Awareness of biases and errors Cognitive forcing strategies Effective feedback Targeted flip classroom approach	<i>It is a common trap to concentrate on the most obvious signs and ignore the underlying pathophysiology. This is the so-called bias of premature closure. Always try to explore the problem in its entirety and do not jump to a closed hypothesis based on the initial impression only.</i>
Inability to detect primary complaint by the client*	Fails to identify primary complaint/s and spends too much time exploring minor points	Early development of hypothesis-driven data collection	<i>Can we start from the beginning? What were the initial thoughts when the client said the reason for the encounter?</i>
Stereotyping	Approach to the encounter rigid, stereotypical, and not tailored to the encounter, client, context, or patient	Effective feedback Multiple opportunities to practice communication and data collection Use of (O)RIME to categorize learners and assist according to development level	<i>Could you explain what context you have considered in this encounter?</i>
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters * May lead to client dissatisfaction	NA

Table S2. Common difficulties/errors in the collection of data during veterinary clinical encounters and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical cognition	Any of the others	Cognitive forcing strategies Effective feedback Targeted flip classroom approach	<i>It seems that the principle of flaccid paresis was detected in this encounter. However, the connection to the presenting problem of protruding tissues from the hind quarters was not made. Could we agree that literature research on this topic is required?</i>
Disorganized data collection*	Collecting irrelevant data; no clear direction; usually unduly long	Effective feedback	<i>Can we discuss our thinking when a client tells us that she calved overnight without assistance and delivered a live, healthy female calf?</i>
	Failure to address key features early	Exposure to complete data collection, but also hypothesis-driven data collection	<i>It is wise to discuss the aims and outcomes of the ancillary technique/test before we order it.</i>
	Failure to collect hypothesis-driven data	Models of clinical teaching (e.g., The Five Microskills—1) Get a commitment; 2) Probe for supporting evidence; 3) Teach general rules; 4) Reinforce what was done well; and 5) Correct mistakes. An additional stage is the ‘Debrief’; SNAPPS—1. Summarize briefly the history and findings; 2. Narrow the differential to two or three relevant possibilities; 3. Analyze the differential by comparing and contrasting the possibilities; 4. Probe the preceptor by asking questions about uncertainties, difficulties, or alternative approaches; 5. Plan management for the patient’s medical issues; and 6. Select a case-related issue for self-directed learning)	<i>Can we discuss our thinking when during initial data collection we find mild tachycardia and muffling of heart sounds?</i>
	Omission errors (e.g., Procedure/Process incomplete; Disregards new prompts)	Role modeling	<i>If we go back to the beginning when the client mentioned the reason for the encounter, the initial thoughts were a prolapsed uterus or vagina or retained fetal membranes. Let’s now think of how we can proceed to collect hypothesis-driven data.</i>
	Profusion with irrelevant data collection	‘Think aloud’	<i>It would be good to discuss the reason a lot of time was spent on exploring biosecurity when the initial investigation and clinical findings were not supportive of the infectious nature of the problem.</i>
Incomplete data collection	Brief but not hypothesis-driven Hypothesis-driven but incomplete	Effective feedback Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Role modeling	<i>What else would be useful to know in this encounter and what could be done to find this information (e.g., nitrogen fertilization history applicable to the offending paddock)?</i>
Premature closure <i>One of the most common errors</i>	Acceptance of data that confirms the hypothesis Failure to explore/notice information that could evoke additional hypotheses	Comparing and contrasting discriminating features of tested hypotheses Effective feedback Practice highlighting discriminating features of tested hypotheses	<i>After the initial intervention on Friday, both the client and we have more time to deal with this encounter. Let’s start with thinking of 3 hypotheses that should be considered and compare and contrast between them.</i>
Feeling under pressure			
Stereotyping*	Data collection is rigid, stereotypical, and not tailored to the encounter, client, context, or patient	Effective feedback Role modeling ‘Think aloud’	<i>When I detect the flaccid muscle paresis I think of myasthenia. The signs of exercise intolerance, muscle weakness, and proptosis may occur with any myasthenia, whilst cardiac, mentation, and respiratory signs are more common in metabolic myasthenia. Therefore, to differentiate between neurologic and metabolic causes that may apply to this encounter, I would enquire about behavior and demeanor at the initiation of the disorder, signs of gait abnormalities and prolonged weakness, but also pay particular attention to the neurologic system during the clinical examination.</i>
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters * May lead to client dissatisfaction	NA

Table S3. Common difficulties/errors in the analysis of data during veterinary clinical encounters and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical knowledge	Any of the others	Cognitive forcing strategies Effective feedback Further education/exposure Targeted flip classroom approach	<i>Could you tell us, based on the signalment and the presenting problem, what is your thinking?</i>
Inability to build an overall representation of the encounter	Addressing each sign/syndrome in isolation/Not open to problem relationships	Cognitive forcing strategies	<i>It would be good to return to the problem representation for this encounter. What connection could be made between the key features?</i>
	Difficulty integrating and synthesizing the information into a meaningful hypothesis	Comparing and contrasting discriminating features of tested hypotheses Drawing concept map Effective feedback	<i>Let's list 3 disorders characterized by flaccid paresis and explain what reasons would include them and what reasons would exclude them from the differential diagnosis list.</i>
	Lack of connection of involvement of multiple organ systems/pathophysiology	Further education/exposure Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Practice highlighting discriminating features of tested hypotheses Semantic qualifiers ‘Think loud’	<i>Can we start with the key features of this encounter and think about what organ systems may be involved?</i>
	Lack of longitudinal perspective regarding the encounter	Use of (O)RIME to categorize learners and assist according to development level	<i>Can we rediscuss detected key features and circumstances that this encounter presented before going into detailed hypotheses?</i> <i>Can we discuss the importance of detecting hypocalcemia and hypomagnesemia in Friday's lab findings to the entire population?</i>
Inability to generate an appropriate/prioritized list of differential diagnoses	Difficulty in formulating and justifying proposed differentials	Comparing and contrasting discriminating features of tested hypotheses Drawing concept map Effective feedback	<i>Can we briefly compare and contrast the main discriminating features of rectal, uterine, and vaginal prolapse? They are all similar but have subtle differences. Alternatively, we can meet this afternoon which would provide some time for reading these three hypotheses.</i>
	Differentials listed without prioritization		<i>Can we have three hypotheses that are defensible for this encounter? What are the distinguishing features of these hypotheses?</i>
	Failure to recognize the key features		<i>It would be great to hear again the summary in the form of problem representation. Then, can we have the justification on the list of hypotheses and, in particular, putting pneumonia on the top of that list?</i>
	Hypotheses do not align with the expected		<i>Can we briefly discuss the ranking of the differential diagnoses listed for this case? To me, it seems illogical to have infectious disorders at the top when there is no evidence of infection.</i>
	The list of differentials is too extensive	Justifying the proposed list of hypotheses Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Practice highlighting discriminating features of tested hypotheses	<i>Could you explain the reason for spending a lot of examination time around the eyes when the problem is at the hindquarters? Can we move on with the examination, please?</i>
	Need for intervention to shift the focus of the encounter	Role modeling ‘Think aloud’	
	Ranking of hypotheses mismatching the encounter		
Incomplete list of differentials	Spending too much time on a minor (occasionally extraneous) issue/problem	Cognitive forcing strategies Effective feedback	<i>Let's think of the problem representation we have in this case. The main pathophysiological sign was protruding tissues from the hind quarters. Could we prepare a DAMNT-V list of potential diagnoses associated with protruding tissues from the hind quarters, including common and ‘must not forget’ hypotheses?</i>
	The list does not encompass common and ‘must not forget’ differentials	Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Practice highlighting discriminating features of tested hypotheses ‘Think aloud’	
Premature closure*	Failure to address information with the capacity to evoke alternative hypotheses	Awareness of common cognitive biases and errors Comparing and contrasting discriminating features of tested hypotheses Drawing concept map Effective feedback	<i>Apart from the single hypothesis that has been discussed, were there any other alternative hypotheses considered and if yes, why they were discarded?</i>
	Scarce elaboration on alternative hypotheses	Justifying the proposed list of hypotheses Reflection	<i>What data did you use to include or exclude the alternative hypotheses you just mentioned for this encounter?</i>
Stereotyping	Data analysis is rigid, stereotypical, and not tailored to the encounter, client, context, or patient	Cognitive forcing strategies	<i>Could we think of the main pathophysiologic mechanism involved with this encounter and what three important hypotheses should be tested?</i>
	Seeking answers in ‘textbook’ encounters only	Comparing and contrasting discriminating features of tested hypotheses Drawing concept map Effective feedback ‘Think aloud’	<i>Yes, the obtundancy, sternal recumbency and tachycardia are all textbook examples of hypocalcemia but the underlying physiology in this case is not. In practice, the textbook examples are very rare. Can we contrast the differences in the pathophysiology to textbooks for this encounter?</i>
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters	NA
* May lead to client dissatisfaction			

Table S4. Common difficulties/errors in identifying problems ± issues during veterinary clinical encounters and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical cognition	Any of the others	Cognitive forcing strategies Effective feedback Targeted flip classroom approach	<i>Clinical reasoning is easier to approach as a problem-solving exercise. For this approach, identification of the key features or problems is essential. Can we concentrate on 3 to 5 key issues identified in this encounter?</i>
Poor issue/problem detection	Difficulty seeing the scope of a problem	Cognitive forcing strategies	<i>Can we discuss the key features identified in this encounter? Can you list three main features of this encounter that you can defend?</i>
	Failure of recognition of the principal issue/problem	Drawing concept map Effective feedback	
Poor problem representation	Lack of recognition of a particular issue/problem/Lack of selection of key features	Models of clinical teaching (e.g., The Five Microskills; SNAPPS) ‘Think aloud’	<i>Can you summarize the main findings of this encounter in one to two sentences? Can you summarize the detected problems that should be considered in creating an appropriate list of differentials? Can you write down the list of problems for this encounter? Can you compare and contrast the retained fetal membranes and prolapsed uterus that you mentioned in your problem representation, trying to use medical rather than layperson terminology?</i>
	Addressing each sign/syndrome in isolation/Not open to problem interpretation and/or relationships	Cognitive forcing strategies	<i>We had an opportunity to hear an excellent description of the health interview, the examination exam, and the laboratory findings. However, we did not hear the interpretation of the information. Based on this, I would say, we heard this learner operates as an excellent Reporter. Take the information to the next level, addressing data you have gathered, sort through it, identify and analyze key information, and form your assessment of the encounter. This would result in moving into the Interpreter level learner. What search terms would you use to assist you in the creation of the potential list of differentials for this case?</i>
	Failure to convert information using semantic qualifiers/Presenting a summary rather than synthesis of data/Use of non-medical terminology	Drawing concept map	
	Incomplete problem representation	Effective feedback	
	Only loosely connected to the encounter	Improving comprehension of knowledge rather than pure recall of facts	
	Overly complex representation (e.g., key features interjected with irrelevant features)	Models of clinical teaching (e.g., The Five Microskills; SNAPPS)	
	Profusion with irrelevant data	Role modeling Shift focus to relevant information only ‘Think aloud’	
Premature closure*	Unclear problem representation		<i>A great list of problems. Can we now have a list of the three differential diagnoses applicable to this encounter that can be defended?</i>
	Lack of differential diagnoses	Awareness of common cognitive biases and errors Effective feedback	<i>You mentioned that the protruding tissues have multiple lumps. Can we discuss the main features of the protruding tissues in the vaginal prolapse and what would be rule-in and rule-out features as seen in this encounter?</i>
	Lack of reporting on information that does not support the hypothesis	Practice highlighting discriminating features of tested hypotheses	<i>Apart from the single differential diagnosis of a prolapsed uterus, were there any other differentials that were considered and please explain the process of elimination?</i>
Reliance on artificial intelligence/information technology	Acceptance of results produced by artificial intelligence without challenge	Cognitive forcing strategies Drawing concept map Effective feedback	<i>We all accept that the use of information technologies is the future. Yet, each output by the information technology should be appropriately challenged. Can you let us know what the inputs into the system were and how these reflect the current encounter?</i>
	Excessive use of artificial intelligence/information technology	Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Practice highlighting discriminating features of tested hypotheses ‘Think aloud’	
Stereotyping	Problem representation is rigid, stereotypical, and not tailored to the encounter, client, context, or patient	Cognitive forcing strategies Drawing concept map Effective feedback ‘Think aloud’	<i>Friday had previously suffered from two bouts of clinical hypocalcemia. As the incidence of hypocalcemia in cows with a history is high, it is logical to conclude that her recumbency is due to hypocalcemia. Yet, the underlying etiology is not established. Can you summarize health interview information and laboratory findings that may assist us in establishing the underlying etiology?</i>
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters	NA
* May lead to client dissatisfaction			

Table S5. Common difficulties/errors in establishing mutually agreed goals during veterinary clinical encounters and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical knowledge	Any of the others	Cognitive forcing strategies Effective feedback Targeted flip classroom approach	Mr Block indicated that he would prefer Friday to survive and return to milk. For the management of this case and the prevention of future cases, hypocalcemia and hypomagnesemia must be prevented. Therefore, Mr Block should be informed of the underlying causes and risk factors. Meaning that client education is essential. Can you explain how you would go about it?
Inappropriate communication*	Inappropriate body language	Awareness of common cognitive biases and errors Cognitive forcing strategies Effective feedback Role modeling ‘Think aloud’	During any encounter, we communicate with the client by verbal, non-verbal, and by tone of voice. Therefore, the body language should be carefully controlled. Are we on the same page?
	Inappropriate vocabulary		Can we try to explain the same to the client using a non-technical vocabulary?
	Lack of integration and synthesis of management approach/es		Could we think of a way to integrate calcium and magnesium intake and control during the transition period?
Inappropriate goals/plan*	Too verbose (‘chatter box’)	Effective feedback Role modeling	Let’s imagine that this encounter was to be presented to a consultant who is talking to us over the phone. What would be the shortest way to present it?
	Difficulty in dealing with uncertainty		
	Lack of longitudinal aspect in the proposed management plan		Let’s think of feelings that may arise from such a proposal.
	Proposed action and outcome are not the best representatives for the encounter		What factors helped you to decide the management plan in this encounter? What helped you to prioritize the client’s/patient’s needs in this encounter? What would be the number one priority for this client in this encounter?
Incompleteness of goals*	Proposed approach offensive	Comparing and contrasting advantages and disadvantages of tested hypotheses Cognitive forcing strategies Effective feedback ‘Think aloud’	
	Aspects of the encounter not addressed		Let’s think of the encounter. We were presented with protruding tissues from the hind quarters and unconscious recumbency. We addressed protruding tissues from the hind quarters well. How could we best address unconscious recumbency in the current goals?
Lack of involvement of the client’s perspective*	The proposed list does not include alternative approaches	Effective feedback Role modeling	
	Lack of recognition of the effect of the issue/problem on the client		It would be good to consider the potential milk quality issues with Daisy being in the herd and how that may affect the client.
Lack of elaboration of the management approach*	Difficulty in presenting the plant to the client	Comparing and contrasting advantages and disadvantages of tested hypotheses Drawing concept map Effective feedback ‘Think aloud’	Can we hear how we arrived at this chosen management approach?
	Failure to present summarized and synthesized information regarding the encounter		Can we have a diagram or mind map drawn explaining main proposed alternatives?
	Failure to inform the client of the expected outcome, the potential need for adjustment, and potential undesirable outcomes		Let’s take a break. During the break, it would be good to research on the potential goals for this encounter. Before we reconvene, it would be a good idea to have a private discussion (without the client’s presence) to iron out a few ideas.
Stereotyping	The proposed management plan is rigid, stereotypical, and not tailored to the encounter, client, context, or patient	Cognitive forcing strategies Effective feedback Role modeling ‘Think aloud’	If we were to prioritize our key findings differently, what effect would that have on the goals for this encounter? If we were to consider XX, YY and ZZ, how that would impact the goals for this encounter?
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters	NA
* May lead to client dissatisfaction			

Table S6. Common difficulties/errors in taking action during veterinary clinical encounters and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical knowledge	Any of the others	Cognitive forcing strategies Effective feedback Targeted flip classroom approach	Before we confirm the agreed management of the case, we may need to consider the priority of each strategy. Can you tell us what made you say that repositioning the uterus is the most important priority, compared to the treatment of hypocalcemia?
Difficulty in elaboration of the management approach*	Delaying the decision for the management approach	Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Effective feedback ‘Think aloud’	Can we briefly discuss the next step in the management of the case, considering it is an emergency?
	Lack of a SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) approach to the management		It would be good to debrief at this moment and briefly compare and contrast the three proposed management strategies, considering their relevance to this encounter.
Stereotyping	Execution of the proposed management plan is rigid, stereotypical, and not tailored to the encounter, client, context, or patient	Effective feedback Role modeling	A brief reflection on the role of disinfectants in cleaning the uterus before repositioning may be beneficial. Can we have a volunteer, please?
	Seeking answers in ‘textbook’ management approaches only		We all know that perfect textbook examples exist only in textbooks. In a real-life situation, it is good to think of acceptable compromises.
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters	NA
* May lead to client dissatisfaction			

Table S7. Common difficulties/errors in evaluating outcomes of veterinary clinical encounters and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical knowledge	Any of the others	Cognitive forcing strategies Effective feedback Targeted flip classroom approach	<i>The evaluation of the efficacy of the preventative strategies for hypocalcemia should consider the current situation within the population but also both forms, clinical and subclinical. It would be good to do some research on options after we return to the clinic followed by a short discussion before we call Mr Block to discuss the options. Can we have a volunteer to take on this task, please?</i>
Inappropriate follow-up*	Lack of follow-up plan	Effective feedback	<i>Could we discuss the encounter of the uterine prolapse that we saw last week? We need to know the outcomes from it.</i>
Inappropriate outcome to evaluate	The outcome is not the best representative of the action taken	Effective feedback	<i>Would you be able to justify your decision that the efficacy of the management of hypocalcemia would be best evaluated using the incidence of prolapsed uteri?</i>
Poor evaluation of the outcome	Difficulty dealing with uncertainty	Drawing concept map Effective feedback Role modeling	<i>Can we discuss the likelihood of being certain of the outcome of fertility for Friday in this encounter?</i>
	Lack of holistic approach to expected outcomes		<i>Could we discuss the benefits and consequences of the proposed management approach/diagnostic tests for Friday and the enterprise?</i>
	Lack of longitudinal perspective in the outcomes		<i>Can we think of long-term solutions for this problem?</i>
	Lack of realization about possible relationship between different aspects of the clinical encounter		<i>Can we think of reasons for a sudden death following our clinical intervention of repositioning the uterus?</i>
	Too rough an evaluation of the outcome		<i>If we were to step back and think of what the client said, are we going to arrive at a decision where the client is not happy with the outcome?</i>
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters * May lead to client dissatisfaction	NA

Table S8. Common difficulties/errors in reflection before, during, and after veterinary clinical encounters, identifying new learning, and their applicable remediation strategies.

Difficulty/Error	Indications	Prevention/Remediation	Example sentence/s
Deficient medical knowledge	Any of the others	Cognitive forcing strategies Effective feedback Reflection	<i>Can you list, using the DAMNIT-V mnemonics, the causes of recumbency in a cow around calving?</i> <i>Please reflect on the common causes of the sign/syndrome you just mentioned.</i> <i>Can you reflect on what management approaches should be considered when seeing the pathophysiologic mechanism of recumbency?</i>
Lack of choice of a self-learning item from the encounter	Difficulty identifying learning issues	Effective feedback Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Reflection	<i>During the debrief, it became obvious that the relationship between hypocalcemia and hypomagnesemia is not well understood. The research on this relationship may be a good choice for a learning issue from this encounter.</i>
	Lack of commitment to self-directed learning		<i>Could we reflect on elements from this encounter that could benefit future encounters?</i>
Lack of metacognition	Lack of consideration of alternatives	Awareness of common cognitive biases and errors Cognitive forcing strategies Effective feedback Hypothesis generation and testing time-out Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Reflection Scaffolding Teamwork	<i>It would be good to hear your reflection on the choice of management of the uterine prolapse in this encounter, explaining the comparison between management approaches.</i>
	Lack of consideration of unexpected outcome		<i>Could you tell us about unlikely but unexpected outcomes related to uterine repositioning?</i>
	Lacking a plan before talking		<i>Would you reflect on your reflection-for-action in this encounter?</i> <i>Can you reflect on your preparation for this encounter?</i>
	Lacking regulation of thinking during thinking		<i>Can you reflect on your thinking about the association between hypocalcemia and hypomagnesemia and the reasons for these becoming ‘muddier’ as the discussion continued?</i>
	Lack of reflection on thinking after thinking		<i>It would be beneficial to think about your stress level and how it has affected your thinking when exposed to an emergency.</i>
	Lacking a plan before the encounter		<i>Can we think of what factors in this encounter may influence our thinking?</i>
Lack of self-reflection	Lacking regulation of thinking during the encounter	Effective feedback Metacognitive forcing strategies Models of clinical teaching (e.g., The Five Microskills; SNAPPS) Reflection	<i>What do you think went well in this encounter and what could be improved?</i>
	Lack of reflection on thinking before, during and after the encounter		<i>Would be good to write a self-reflection essay addressing this encounter.</i> <i>What do you think could be done differently in this encounter and the future?</i>
Any	Any	Repeated practice with a variety of simulations, followed by a variety of encounters	NA

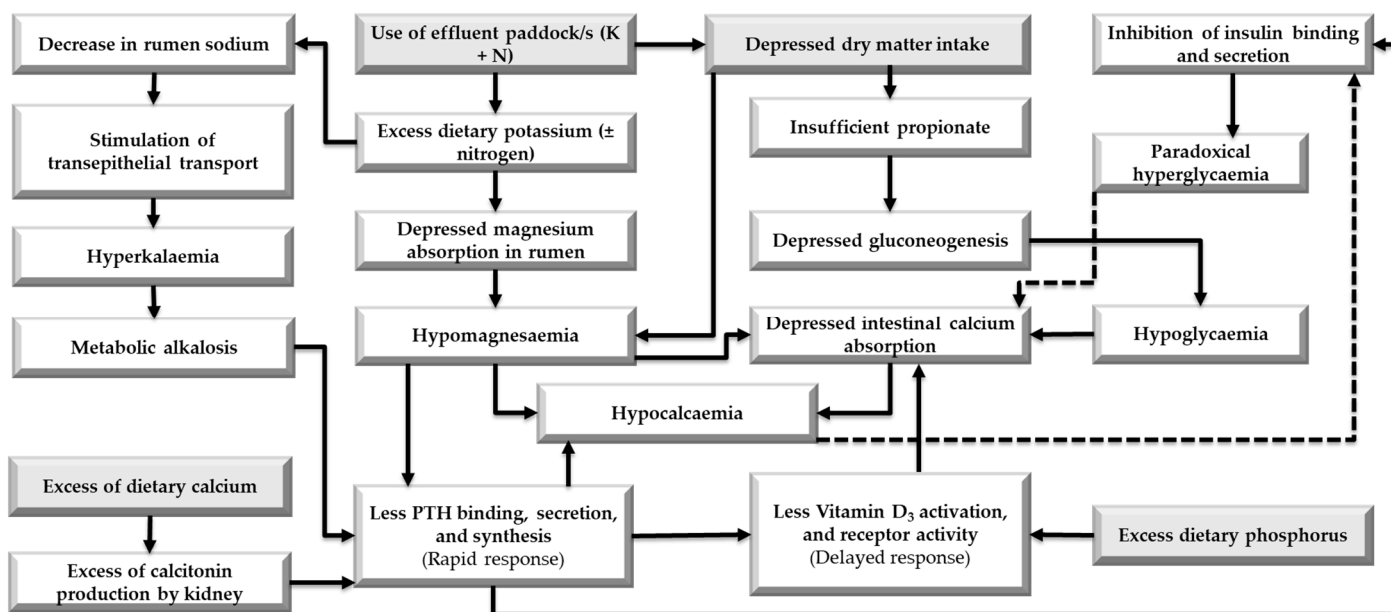


Figure S1. Diagram presenting the common risk factors and pathophysiology of hypocalcemia and hypomagnesemia. The uterine prolapse in the example case is associated with both of these conditions.

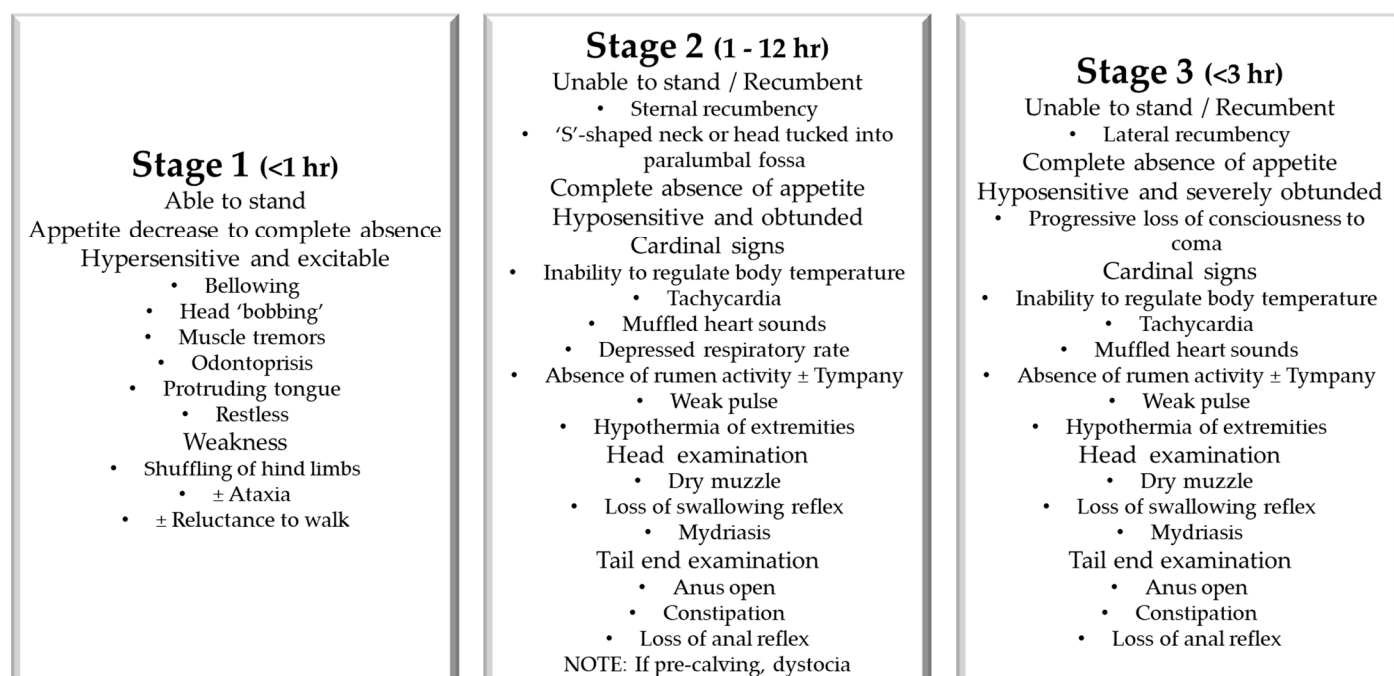


Figure S2. Summary of common clinical findings in various stages of hypocalcemia in cattle and typical duration (in the brackets for each stage).