Training method and other factors affecting student accuracy of bovine pregnancy diagnosis

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Abstract

To optimize bovine pregnancy diagnosis (PD) training, factors influencing student performance were investigated. The objective was to determine whether training method, gender, background (farm, urban, or mixed), previous experience in bovine PD and current career interest influenced the accuracy of bovine PD by trans-rectal palpation (TRP).

Fourth year (of a 6-year program) veterinary students (n = 138) received one PD training session in groups using either simulator training on Breed'n Betsy® (BB) or training on live cows (C). Students completed a questionnaire on gender, background and career interest. Students' PD accuracy (pregnancy status and stage) was determined after training when each student palpated six cows with known pregnancy status. Students' accuracy in determining pregnancy status was measured as sensitivity and specificity (the ability to correctly identify the presence and absence of pregnancy respectively).

Factors that influenced overall accuracy with a higher student sensitivity of bovine PD by TRP were training method, farming background, an interest in mixed animal career and stage of gestation. Gender of students and previous experience in bovine PD did not have an influence. Training on BB simulators was associated with lower student sensitivity for pregnancy detection in cows <6 months pregnant. Student sensitivity for pregnancy detection in cows >6 months pregnant was similar for training on BB simulators and live cows. None of the evaluated factors were significantly associated with specificity of PD. Teaching efforts focusing on specificity of PD and repeated simulator-based training in conjunction with live cow exposure are recommended.

Key words Veterinary education, bovine pregnancy diagnosis, Breed'n Betsy® rectal examination simulator, veterinary students, simulation, demographic

Introduction

Pregnancy diagnosis (PD) by trans-rectal palpation (TRP) is commonly performed by veterinarians according to a well-defined method.[1, 2] In brief, palpation of the female reproductive tract is done through the rectal wall in order to determine positive signs of pregnancy as well as gestational age. While previous researchers suspected that early pregnancy diagnosis by TRP may cause embryo losses,[3, 4] more recent publications indicate that these losses most likely occur regardless of palpation.[5-8] Due to its economic importance and wide use in veterinary practice,[8-14] bovine PD by TRP is an important competency for veterinary graduates,[15] as indicated in Day 1 competency lists published by the Royal Veterinary College and the South African Veterinary Council (www.rcvs.org.uk; www.savc.org.za). However, because of limited resources, increasing student numbers, availability of teaching animals and welfare issues, training opportunities on live animals in general are constrained,[16] and thus also influence PD training for veterinary students. The implementation of bovine rectal examination simulators like the Haptic cow (Virtalis Ltd, United Kingdom, www.hapticcow.com),[17] or the Breed'n Betsy® (Brad Pickford, Australia, www.breednbetsy.com.au) into veterinary teaching programmes, offers additional training opportunities to live cow training,[18-20] and may help reduce the requirement of live animal training. Several studies have evaluated rectal examination simulators,[18-21] and concluded that training on simulators was superior to theoretical instruction only for locating the uterus and cervix,[21] while additional simulator training after live cow palpations significantly improved students' performance.[18] Bossaert et al. (2009), using the Breed'n Betsy® (BB) simulator and live cows, showed students trained on live cows were more skilled evaluating the uterus and ovaries in non-pregnant cows while there was no difference between the two training groups in recognizing pregnant cows by TRP.[20]

Some studies have evaluated the effect of upbringing location, gender and previous pet ownership on career choice of veterinary students.[22-26] Two of the key demographics shown to be positively correlated to a career in mixed or food animal practice are an upbringing in a small centre or rural area and being male.[22, 24, 25] Experience working on a farm,[25] and other agricultural exposure was positively associated with a preference for food animal employment.[26] It is hypothesized that some of the factors that have been shown to have an influence on career choice, might also influence students' performance in bovine PD. The authors are not aware of publications linking factors that influence an interest in mixed or food animal practice to core skills like bovine PD via TRP.

In order to optimize PD training, the factors influencing student performance need to be investigated and the objective of this study was therefore to determine if training method (using either the BB rectal examination simulator or live cows), gender, background (farm, urban, or mixed), previous experience in bovine PD and current career interest influence the accuracy of bovine PD by TRP of fourth year veterinary students.

Materials and Methods

The fourth year veterinary curriculum of the University of Pretoria's 6-year program includes a one-year module on veterinary reproduction during which the theory of bovine PD is lectured to students prior to the onset of practical training. The latter consists of TRP on non-pregnant cows followed by bovine PD via TRP to recognize pregnancy status (yes/ no) and stage of pregnancy. For purposes of this observational study, fourth year veterinary students (n = 138) were assigned to six equal exposure cohorts within two different training programs. Three cohorts of students were assigned to PD training via TRP on the BB rectal examination simulator, and the other three cohorts were assigned to training on live cows. Pre-existing practical groups (assigned according to an alphabetical class list) were used as cohorts and randomly assigned to training method.

The BB rectal examination simulators are models consisting of a steel frame with latex artificial cow perineum at the height similar to that of a cow, and with latex artificial rectum and female reproductive organs that are attached with spring-loaded clamps for easy removal and replacement.[20] After lubrication, a gloved hand is introduced into the artificial rectum, and the organs are palpated through the rectum. The latex artificial reproductive organs are designed to simulate weekly pregnancy stages from six weeks to 20 weeks of gestation. Additional to this, rubber tubes simulating the size and consistency of the uterine arteries, and wooden disks simulating the size of cotyledons during the later stages of pregnancy were made available to students outside of the BB simulator to practice palpation skills. Three BB rectal examination simulators were set up in order to ensure palpation without visualization, whereas other students were encouraged to observe the palpation and to interact through peer instruction. Reproductive tracts were exchanged in order to ensure exposure of all students to all available gestational ages (6, 7, 8, 9, 10 and 11 week pregnancy, 3-5 month pregnancy and non-pregnant uterus). One facilitator coordinated the training for all three cohorts trained on BB rectal examination simulators.

The live cows used for PD training were primiparous and multiparous Bonsmara cows from the University of Pretoria's beef herd located on a farm 20km east of Pretoria, South Africa. Cows used for training were either in the last trimester of pregnancy (7 – 9 months pregnant) or not pregnant, due to the time of the year during which training was done in relation to the breeding season. After application of a rectal glove and lubrication, students were allowed to palpate cows trans-rectally, and were individually assisted by the facilitator explaining what was supposed to be palpated in individual cows. Students were encouraged to palpate at least ten cows and to record and discuss their palpation findings with each other and with the facilitator. No cow was palpated more than three times. One facilitator (not the same as for the BB training) coordinated the training for all three cohorts trained on live cows.

Immediately after the PD training session, all students (BB and C cohorts) were asked to write down the number of PDs performed during the training and were encouraged to give comments about the training session (BB or C).

All students visited a commercial Nguni beef cattle herd three weeks after training where their accuracy to correctly diagnose pregnancy status and stage by TRP was assessed. All cows were uniquely identified. On this day each student completed a questionnaire (Appendix 1). Following completion of the questionnaire each student was offered 12 minutes to palpate a maximum of six cows trans-rectally of which the pregnancy status and stage was pre-determined by a specialist veterinarian experienced in bovine PD via TRP. Individual cows were palpated by either two or three students. Each student's pregnancy diagnoses (pregnancy status and stage) were recorded on an individual data capture sheet against the appropriate cow number. Students were blinded to each other's diagnoses and cows entered the crush in their own order of preference.

Data per palpation performed were transferred from individual data capture sheets into a computer spreadsheet. Categorical data were described as frequencies, proportions, and 95% confidence intervals (CI). Student overall accuracy of PD was estimated as the proportion of correct diagnoses (pregnant or not pregnant, and correct staging of pregnancy where applicable according to the experienced veterinarian). Student sensitivity of pregnancy detection was estimated as the proportion of correctly identified pregnancies and included staging. Student specificity was similarly estimated as the proportion of cows correctly identified as not being pregnant. Proportions and CI were estimated using mixed-effects logistic regression because each student performed examinations on multiple cows and each cow was examined by multiple students. Models included random effect terms for student and cow and a fixed effect for exposure to BB or live cow training. Univariate associations between student sensitivity and specificity were also estimated using mixed effects logistic regression. Multivariable models were fit using a backwards stepwise process based on Student t statistic P values starting with all predictors that had $P < 0.20$ in the univariate screening models until only independent variables with $P < 0.05$ remained. Statistical analysis was performed in commercially available statistical software (IBM

SPSS Statistics Version 22, International Business Machines Corp., Armonk, NY, USA). Unless stated otherwise, results were interpreted at the 5% level of significance.

This study was approved by the Animal Ethics Committee of the University of Pretoria (Protocol V052 / 14).

Results

The study population consisted of 138 fourth year veterinary students of which 94 students were female and 44 male (68% and 32%, respectively). Sixty-three out of 94 female students (72%) and 17 out of 44 male students (45%) were from a city background. Analysis of correctly completed questionnaires (n=126) showed that 39%, 33%, 17% and 9% of students indicated a career interest in small animal practice, mixed animal practice, other (specialized production animal practice, wildlife, state veterinary services, research, industry) and equine practice respectively, whereas only a very small proportion (2.4%) of students did not have a career interest.

Fourty-four students (35%) had bovine PD via TRP experience before the PD training session on BB or live cows, while 82 students (65%) had no experience. Out of the 44 students with previous experience, 28, 7, 6 and 3 students had performed 0-10, 10-25, 25-50 and more than 50 (range 50-500) bovine PDs via TRP, respectively, before the PD training session.

Students in the BB rectal examination simulator training group performed between four and 26 PDs via TRPs (mean 11, median 8) during the training session. Students in the live cow training group performed between four and 18 PDs via TRPs (mean 12, median 8) during the training session.

On the day of practical assessment, 463/749 (62%) student palpations were performed on pregnant cows, of which 213 were on cows <6 months (46%) and 250 were on cows >6months (54%) pregnant. Compared to the diagnoses (pregnancy status) provided by the experienced veterinarian, the mean overall accuracy of pregnancy detection was 68% (95% CI 61% – 74%) and 73% (95% CI 66% – 78%) for students trained on BB rectal examination simulators and live cows respectively ($P = 0.20$).

Factors that were significantly associated with higher student sensitivity of PD in the univariate analysis were students with a farming background, students interested in a mixed animal practice career and stage of gestation (Table 1). Gender of students and previous experience in bovine PD did not have an influence on sensitivity of PD (table 1). Although not statistically significant, student sensitivity of pregnancy detection tended to be lower for those that were trained on BB compared to those trained on live cows. Students trained on BB rectal examination simulators had significantly lower sensitivity to detect pregnancy in cows <6 months pregnant than students trained on live cows. Farming background and pregnancy stage remained significant within the multivariable model (Table 2). Training method was forced into the final multivariable model and the measured effect was similar to the results of the univariate analysis.

None of the evaluated factors were significantly associated with the specificity of pregnancy detection (data not shown). Specificity of pregnancy detection was generally significantly lower than sensitivity and was similar for students trained on BB rectal examination simulators and those trained on live cows (Table 3).

Variable	Level	Parameter estimate (*β*)	Odds ratio (95% CI)	P-value
Training method	Breed'n Betsy®	-0.559	0.57 (0.31, 1.07)	0.08
	Live cows	Referent	-	
Gender of student	Female	-0.558	0.57 (0.27, 1.20)	0.14
	Male	Referent	-	
Background of student	Farm	1.152	3.16 (1.12, 8.93)	0.03
	Mixed	0.649	1.91 (0.85, 4.33)	0.12
	City	Referent	-	
Career choice of student	Mixed practice	1.137	3.12 (1.35, 7.22)	< 0.01
	Other	0.534	1.71 (0.86, 3.40)	0.13
	Small animal	Referent	-	
Previous experience	Non veterinary	-0.102	0.90 (0.40, 2.04)	0.806
	With veterinarian	0.719	2.05 (0.83, 5.11)	0.121
	None	Referent		
Pregnancy stage	2-3 months	Referent	-	
	4 months	0.267	1.31 (0.42, 4.03)	0.64
	5 months	0.518	1.68 (0.48, 5.88)	0.42
	6 months	1.679	5.36 (1.48, 19.4)	0.01
	7 months	1.063	2.89 (0.92, 9.08)	0.07
	8-9 months	2.125	8.37 (2.39, 29.4)	<0.01

Table 1: Univariate results of factors associated with student sensitivity of pregnancy detection.

Variable	Level	Parameter estimate (*β*)	Odds ratio (95% CI)	P-value
Training method*	Breed'n Betsy®	-0.600	0.55 (0.29, 1.05)	0.07
	Live cows	Referent	-	
Background of student	City	-0.838	0.43 (0.21, 0.88)	0.02
	Farm or mixed	Referent	-	
Pregnancy stage	<6 months	-1.261	0.28 (0.15, 0.53)	<0.01
	≥6 months	Referent	-	

*Forced into model

Table 2: Multiple regression model of factors associated with student sensitivity for pregnancy detection (all stages of pregnancy).

Cows	Training method: Breed'n Betsy®		Live cows	
	Sensitivity (%)*	Specificity (%)*	Sensitivity (%)*	Specificity (%)*
All cows	84[b] (78, 89)	39[c] (30, 49)	90[b] (85, 94)	42[c] (33, 52)
< 6 months pregnant	68[a] (54, 79)	n/a	84[b] (72, 91)	n/a
≥ 6 months pregnant	91[b] (85, 95)	n/a	93[b] (87, 97)	n/a

*Mean (95% CI)
[a,b,c]Means with different superscripts differ significantly after Bonferroni correction of P values for multiple post-hoc tests ($P < 0.05$)
[n/a]Not applicable

Table 3: Mean student sensitivity and specificity for pregnancy detection by training method.

Discussion

In this study, overall accuracy of pregnancy diagnosis (pregnancy status and stage) was lower than what is considered acceptable accuracy for veterinarians.[3, 9, 27, 28] Although the time limit placed on students to complete the PDs may have affected their accuracy, the low accuracy is supported by Bossaert et al. (2009) who showed that students need extensive exposure to TRP in live cows as 200 TRPs were insufficient to ensure complete competency.[20] Students in the current study were exposed to one introductory TRP on non-pregnant cows before the PD training session by TRP in cattle or on BB rectal examination simulators and although by the time of the practical assessment each student had performed between 6 and 28 TRPs, this was most likely insufficient to prepare students to correctly correlate clinical findings to a diagnosis. On the other hand, it was previously shown that a single training session on any one of two simulators (Haptic cow or BB rectal examination simulator) was superior to theoretical instruction in terms of ability to localize uterus and cervix.[21] Pregnancy diagnosis training should therefore aim at increasing palpation competency in veterinary students by providing sufficient palpation sessions. Rectal examination simulators can help overcome the deficiency in availability of teaching animals if training is provided in conjunction with live cow exposure. This approach will not only result in higher competency levels amongst students for TRP if repeated simulator training is offered before the first live cow palpation, but also help avoid overuse of and too many palpations on teaching animals which is a welfare concern at teaching institutions. Only 35% (44/126) of students had previous experience in bovine PD via TRP before the training session on BB rectal examination simulators or live cows. The fact that out of those 44 students only three had extensive experience (>50 PDs via TRP) indicates that bovine PD opportunities outside the veterinary training program are limited and not easily accessible to students. Furthermore, this might be an explanation as to why the demographic factor "previous experience" did not significantly affect student sensitivity of PD in this study and confirms that rectal palpation competency requires extensive exposure.[20]

The relatively low proportion (62%) of pregnant cows examined on the day of the practical assessment might have influenced sensitivity and specificity estimates. It is possible that students expected to perform pregnancy diagnoses in a herd with a higher pregnancy proportion, in which case if any doubts existed on the pregnancy status of a cow, the student would have been more likely to guess that the cow was pregnant. It is hypothesized that this contributed towards substantially lower student specificity compared to sensitivity in this trial. The fact that no predictors of specificity could be demonstrated in our data may therefore be attributed to guessing on the part of the students and their tendency to value sensitivity higher than specificity. Although false negative pregnancy diagnosis has an obvious disadvantage, in particular where cows that are not pregnant will be slaughtered, false positive pregnancy detection also has significant negative impact on farm profitability.[3, 29] Based on this and our data we suggest that teaching efforts should focus on the specificity of pregnancy detection, and less on sensitivity. Training of students to palpate non-pregnant cows is likely to improve specificity of pregnancy diagnosis and is for this reason an appropriate strategy to obtain some of the initial skills for PD.

Although career interest was associated with student sensitivity of pregnancy detection in the univariate analysis, this appeared to have been confounded by the background of the student because it did not remain significant in the multivariable model that included farming background. This could indicate that the experience of living and working on a farm is not only positively associated with an interest in large animals,[25, 26] but might also have an effect on initial large animal clinical skills.

The lower sensitivity of pregnancy detection in early stages of pregnancy in our data is in agreement with previous findings.[3] It was interesting to find that student sensitivity in early pregnancy was lower for students trained on BB rectal examination simulators, because the simulators are specifically designed to detect early pregnancy, and do not simulate pregnancy stages beyond five months. It may therefore be that if a higher proportion of cows were in early stages of pregnancy during the practical assessment, a more significant exposure effect due to training method may have been demonstrated. In this study, the cohort of students that were trained on live cows were not exposed to early pregnancy stage during training, but they were more sensitive for early pregnancy during the practical assessment. Reasons for this paradox needs further investigation, but taking students' comments into consideration, it appears that the unusual experience of TRP may be greater to overcome, than the actual ability to palpate. Students trained on BB rectal examination simulators indicated that the simulator based PD training is a good starting point to learn bovine PD. Positively perceived features were the visualization of structures palpated and the ability to palpate different pregnancy stages consecutively which increased the understanding of pregnancy stages. However, many students indicated that the simulator training should be followed by a TRP session for PD in live cows to maximize the learning outcome. Some students with previous PD experience via TRP in live cows made negative remarks about the simulator experience while students without any prior live cow PD experience were exclusively positive. In general, it may be beneficial to focus on additional simulator-based training to increase competence and palpation accuracy amongst students before performing TRPs on live cows.

Demographics of the study population showed that 63 out of 94 female students (72%) and 17 out of 44 male students (45%) were from a city background, and more students from a city than from a farm background selected small animals as a career interest, which is in agreement with previous findings,[24] and confirms that a farming background is positively associated with an interest in large animal practice.[25, 26]

The proportion of students choosing mixed practice as career interest was not affected by gender, which is in contrast to previous studies where male veterinary students were significantly more likely to choose a farm animal or mixed practice career than female students.[22, 25, 30] Female and male students from a farming background showed equal interest in mixed practice, which supports previous findings that a rural upbringing,[22, 30] as well as the likely associated agricultural experience with the rural upbringing increases an interest in farm animal practice, [25, 26] This previous experience and interest in large animals seems to be positively correlated to large animal clinical skills such as bovine PD via TRP.

It may have been better to use the phrase "career interest" instead of "career choice" in the questionnaire to ensure student answers were based on their actual interest. "Career choice" could have left room for students to indicate choices based on practical or economic reasons rather than main interest.

Conclusions

Factors that influenced overall accuracy of bovine PD by TRP with a positive effect on student sensitivity were training method, farming background, an interest in mixed animal career and stage of gestation. Training on the BB rectal examination simulator was associated with lower student sensitivity for pregnancy detection in cows <6 months pregnant while no difference could be shown between the training groups in cows >6 months pregnant. None of the evaluated factors were significantly associated with specificity of pregnancy detection. It was therefore concluded that teaching efforts should focus on the specificity of pregnancy detection to obtain some of the initial skills for PD, and repeated simulator based training in conjunction with live cow exposure is an appropriate strategy to increase students' competency levels for bovine PD via TRP.

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Appendix 1

2014 OP PD Challenge student questionnaire

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Student: Student number: Group:

Gender: Male ☐ Female ☐

Back-ground: Farm ☐ City ☐ Mixed ☐

Experience in bovine pregnancy diagnosis/rectal palpation prior to OP PD Challenge:

- Only what I've done at Onderstepoort ☐
- Some previous exposure without a veterinarian ☐
- Some previous exposure with a veterinarian ☐
- Extensive previous exposure ☐

Indicate no of PDs done in total prior to OP PD Challenge ☐

Exposure obtained since start of OP PD Challenge:

- Only one training session as provided ☐
- Some additional exposure without a veterinarian ☐
- Some additional exposure with a veterinarian ☐

Indicate no of PDs done in total since start of OP PD Challenge ☐

Current career choice:

- Small animal practice ☐
- Rural (mixed) practice ☐
- Equine practice ☐
- Specialised production animal practice ☐
- Specialised wildlife practice ☐
- State veterinary practice ☐
- Research/Academia ☐
- Pharmaceutical industry ☐
- Other ☐

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