Chapter 6

The effect of e-learning on the quality of cervical length measurements

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Ultrasound in Obstetrics & Gynecology. 2014 Dec 11

Abstract

Objective: Training in ultrasonography is frequently performed hands-on along with an experienced sonographer. With the introduction of cervical length (CL) measurement in a research setting, a CL measurement e-learning module (CLEM) was developed with the purpose to enhance the knowledge and skills of experienced ultrasonographers. CLEM was designed especially for ultrasonographers who perform ultrasound in a general obstetrical practice, but do not regularly perform CL measurements. In this case-control study we assess the effect of CLEM on the quality of cervical length measurements comparing CLEM trained and non-CLEM trained ultrasonographers.

Methods: The CLEM consists of five theoretical questions and three caliper placing tests to acquire the cervical length measurement technique. The quality of the CL measurements of CLEM participants was compared to images of non-participants using a CL measurement image score (CIS) defined as the sum of six items which assess the quality of the image. Each CLEM participant submitted five cervical length images. The images of non-CLEM participants were randomly selected from an ultrasound database.

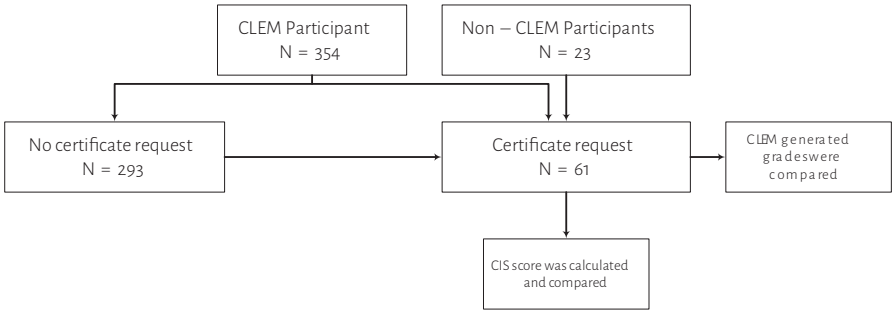
Results: The CL image score of the CLEM participants (n= 61) was significantly higher than the CIS of non-CLEM participants (n= 23, 164.9 vs. 155.6 respectively, $p = 0.03$). Visibility of the internal os and positioning of the calipers on internal and external os was found to have a significantly higher CIS score in the CLEM participants compared to non-CLEM participants ($p = 0.001$ and $p < 0.001$).

Conclusion: The CLEM might improve the quality of CL measurements performed by trained and untrained sonographers.

Introduction

Mid-pregnancy cervical length measurement by transvaginal ultrasound is a tool to assess the risk of preterm delivery. Cervical length measurement is accurate, highly reproducible and reported to have a minimal degree of discomfort for women[1,2].
The reduction of prematurity has become an important goal of the global community because preterm birth was recently marked as one of the main causes of global burden of disease[3]. The impact on public health due to prematurity has resulted in extensive attention to this subject in scientific research.
Hands-on teaching by an experienced sonographer is a well-established method of education and training of ultrasonographic skills and measurements. E-learning however, is an upcoming and powerful tool[4,5]. E-learning is already used as a training tool in disciplines that focus on imaging, like radiology and rheumatology[6,7]. Some educators state that interactive computer programs are more powerful than traditional lecture-based formats and in some cases may replace them[8].
Since cervical length is not routinely measured in low-risk settings such as community ultrasound centres and midwifery practices, the majority of sonographers do not perform cervical length measurements regularly. A cervical length measurement e-learning module (CLEM) was developed with the purpose to improve the level of basic knowledge on cervical length measurement in experienced sonographers. Our goal was to improve the quality of cervical length measurements in order to perform a national multicentre prospective cohort study with a randomised controlled trial embedded; Preventing Preterm birth with Progesterone: costs and effects of screening low-risk women with a singleton pregnancy for short cervical length, the Triple P study (NTR 2078) [9]. We offered the CLEM to sonographers working in primary, secondary and tertiary care institutions in the Netherlands.
The aim of this study was to assess the effect of a cervical length e-learning module (CLEM) on the quality of cervical length measurements by ultrasonographers in asymptomatic low-risk pregnancies (figure 1).

Figure 1. Study flowchart, showing the major comparisons made in the study. CLEM (cervical length e-learning module), CIS (cervical length measurement image score)



Methods

Between January 2010 and May 2011, the sonographers of seven university hospitals, 23 general hospitals and 29 ultrasound centres were asked by e-mail to participate in the e-learning module. Furthermore the CLEM was promoted during several national meetings and conferences and was free of cost. Accreditation by the Dutch society for obstetric sonographers could be obtained by successful completion of the CLEM and submission of five cervical length images. Once certified, sonographers were allowed to measure cervical lengths for the Triple P study. The module can be accessed through the following link: https://www.medischonderwijs.nl/lessonid=1483 or through the Triple P study website: www.studies-obsgyn.nl/triplep.

Web based learning module

In the CLEM, text with theoretical background, links to scientific papers and useful parts in textbooks were offered. Furthermore, the CLEM consisted of five theoretical questions (table 1). There were three caliper placing tests to acquire the skill of the cervical length measurements on three different cervical length images (figure2). Image recognition and calliper placing were practised on ultrasound images. After completing the CLEM, a grade was generated by the module. This grade is an absolute score, in which the grade was the quotient of the questions answered correctly and the total number of questions, normalized between 0 and 10, rounded to one decimal. Definitions of a correct answer are given in table 1. After completion, the CLEM participants automatically received e-mail with the results expressed in a grade from 0-10. The CLEM participants had to have at least 60% of the answers correct before being able to receive the certificate.

The software from the e-learning provider was capable to produce data concerning the number of participants that attempted to finish the module, the time spent by a participant to finish the module, percentages answered correctly and incorrectly per question and the grade generated by the module for each participant. The grades of the CLEM participants who sent in images in order to receive a certificate were compared to the grades of CLEM participants who did not request a certificate.

Figure 2. Caliper placing, measuring the cervical length on one of the CLEM pages.

Competency assessment

In order to explore whether the CLEM contributed to qualitatively better cervical length measurements, two groups of images were examined. The first group of images was submitted by CLEM participants after finishing the e-learning module in order to receive a certificate. These sonographers worked in primary, secondary and tertiary care institutions, and had to be certified to participate in the clinical trial mentioned earlier. Therefore there was some time pressure to finish this training. The second group of images (the control group) was randomly selected from an ultrasound database consisting of images of sonographers from primary, secondary, tertiary care institutions with the same degree in basic ultrasonography as the CLEM participants. The sonographers who performed the measurements on the images in the database had not participated in the CLEM.

The scores of the two groups of sonographers were compared to assess whether the e-learning module contributed to better quality images. Outcome measure consisted of a score, which is based on a scoring system: cervical length measurement image scores (CIS). The CIS was composed to assess the quality of the images (table 2).

Table 2. CIS items

		Poor	moderate	good
1	visibility of the endocervical mucosa	1	2	3
2	visibility of empty bladder	1	2	3
3	visibility of the internal os	1	2	3
4	visibility of the external os	1	2	3
5	positioning of the callipers on internal and external os	1	2	3
6	pressure on the probe	1	2	3

The CIS contained six items about the quality of the image, each item was granted one, two or three points, depending on a poor, moderate or good score. The assessment was performed on five images of each ultrasonographer by two senior ultrasound supervisors independently (MH, EP). The CIS was validated by the two senior ultrasound supervisors by assessing five cervical length measurements and comparing the CIS outcomes with each other. The examiners were blinded for the origin of all the images. Examples of images are given in figure 3,4,5.

Figure 3. Examples of correct caliper placement. Image of a cervical length with correct placement of the calipers on the internal and external os.

Figure 4. Example of an incorrect cervical length measurement. The endocervical mucosa in not completely visible because the ultrasonographic plain is not correctly midsaggital, therefore the internal os is not visible, resulting in incorrect caliper placement. The external os is not visible on the image therefore the caliper is also placed incorrect.

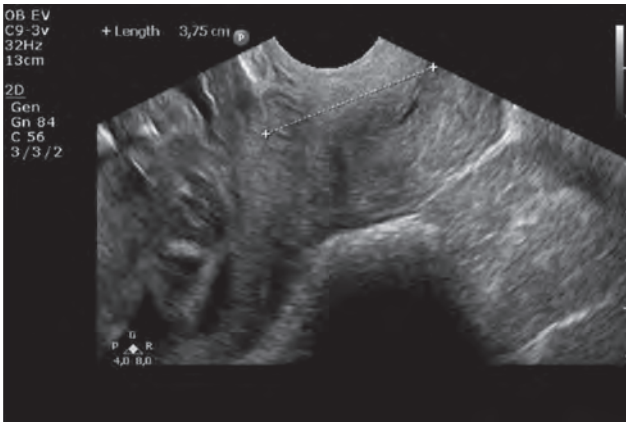


Figure 5. Example of an incorrect cervical length measurement. There is too much pressure on the probe, causing the endocervical mucosa to be not completely visible and the calipers placed incorrectly.

The maximum score was 18 points per image. With five images scored, the maximum score that could be obtained was 90 points per sonographer. The scores of the two supervisors of each ultrasonographer were added, thus the total maximum score was 180 per sonographer.

Furthermore, the CIS scores were compared to the CLEM generated grades of the participants, to assess whether there was a correlation between the results of the e-learning module and the quality of the images.

Statistical analysis

Statistical analysis was performed using SPSS 21. To compare the results of the participants of the CLEM and the sonographers that did not participate in the CLEM Mann Whitney U test was used. To assess whether there was an association between the results of the CLEM and the CIS scores a Pearson's linear regression test was used.

Results

Between January 1st 2010 and May 5th 2011, 354 sonographers trained themselves with the CLEM. Response rate cannot be calculated because the CLEM is free accessible to anyone via the internet. The sonographers spent 17 minutes on average per completed session. The total number of sessions of this group was 1118, which is 3.16 session per sonographer.

Of the 354 CLEM participants 61 sonographers submitted five images in order to receive a certificate. The mean grade generated by the module, for the CLEM participants who did not submit images (N= 293) was 5.7, compared to 6.9 for the group that submitted images and requested a certificate (N=61), which was significantly higher ($p < 0.01$).

Of all questions answered in the CLEM, question number one and seven (table 1) were answered incorrectly most frequently. Question number one concerned an estimation of the chance of preterm delivery with a cervical length of 25 mm at 23 weeks of gestation. The correct answer of this scale question was a range between 4% and 6%[10]. This answer was given only in 46% of the 354 participants, 36% overestimated and 18% underestimated the chance of preterm delivery. Question number seven concerned the actual measurement of the cervical length by placing callipers on a high quality ultrasound image of a cervix in a midsaggital plane. Correct placing was done by 48% of the ultrasonographers, while 35 % overestimated and 17% underestimated the cervical length. Other results of the CLEM questions are shown in table 1.

Table 1. CLEM questions

Question	1Question composition 2 Type of question 3 Definition of positive score	Correct answer N=354
1	1 Risk assessment of a preterm birth with a short cervix of 25 mm. 2 Scale question 3 The scale is posted inside or on the boundary of a proper range.	46%
2	1 Image recognition of a correctly performed cervical length measurement. 2 Picture labelling 3 All labels are placed in the correct location.	77%
3	1 Image recognition of too much pressure on the probe, with the recognition of overestimating the cervical length. 2 Fill in the blanks, with selection list 3 More correct answers than wrong answers	66%
4	1 Image recognition of the external os, internal os funnelling and the endocervicalcanal. 2 Picture labelling (identification of structures) 3 All labels are placed in the correct location.	89%
5	1 Caliper placing exercise. 2 Scale question 3 The scale is posted inside or on the boundary of a proper range.	77%
6	1 Caliper placing exercise. 2 Scale question 3 The scale is posted inside or on the boundary of a proper range.	68%
7	1Caliper placing exercise. 2 Scale question 3 The scale is posted inside or on the boundary of a proper range.	47%
8	1 Percentage assessment of inter and intra observer difference between two measurements. 2 Fill in the blanks, with selection list 3 More correct answers than wrong answers	53%

Competency assessment

Cervical length measurements of the 61 CLEM participants that sent in five images and a control group that did not participate in the CLEM (N=23) were assessed with the CIS. The CIS of the CLEM participants (N= 61) was significantly higher than the CIS of the non-CLEM participants (N=23) (164.9 vs. 155.6, p=0.03). The six items of the CIS were analysed separately. Item three (visibility of the internal os) and five (positioning of the callipers on internal and external os) were significantly better in the CLEM participants compared to the non-CLEM participants ($p = 0.001$ and $p < 0.001$, table 2). Item four (visibility of the external os) and five (positioning of the callipers on internal and external os), scored poorly in both groups (table 3).

The CLEM generated grades were compared to the CIS of CLEM participants. There was no correlation found, a linear relationship between the grades and quality scores could be assumed, but the correlation coefficient was 0.17 which was not significant ($p = 0.19$).

Table 3. CIS for the e-learning and control group

Item number	CLEM (mean score)	Controls (mean score)	P value
1	27.7	26.8	0.26
2	27.0	26.9	0.19
3	28.7	26.9	0.001
4	27.6	24.6	0.06
5	26.9	23.2	0.00
6	27.0	27.2	0.67
Total score	164.9	155.6	0.03

Discussion

In this study, we showed that a cervical length e-learning module (CLEM) might improve the quality of cervical length measurements. The quality of the cervical length measurements by sonographers who performed the CLEM was significantly better than the quality of cervical length measurements by sonographers who did not perform the CLEM. The items that showed the largest difference between the trains and non-trained groups were the visualisation of the internal os and the positioning of the calipers on internal and external os. These aspects were well addressed in the CLEM. The mean grade generated by the module was higher for the CLEM participants who did submit images compared to random users of the CLEM who did not submit images. There was no correlation found, between the CLEM generated grades and the CIS of CLEM participants.

This new module was developed with the goal to focus on practical exercise by caliper placing and image recognition. This was done instead of using the already existing cervical length e-learning module of the The Fetal Medicine Foundation, which focusses mainly on theory by explaining the technique of measuring cervical length and the clinical applications of this measurement. The major difference between the two courses is that ours focusses more on practical exercise.

The fact that the mean grade generated by the module, for the CLEM participants who did submit images was higher compared to random users who did not submit images might have been expected given the higher initiative and motivation of the sonographers that wanted the certificate and the fact that they had to have at least 60% of the answers correct before being able to receive the certificate. The certification was used as a requirement for participation in a randomised clinical trial, so it was not completely voluntary.

The discrepancies between the CLEM generated grades and the CIS of the CLEM participants might be explained by the fact that the CLEM grade was based on a combination of theoretical questions and caliper placing tests practicing measurement technique, while the CIS only assessed the technical execution.

Few other studies have focused on image recognition through e-learning modules. Marks *et al.* compared accuracy of image recognition by asking students to score standard neonatal renal ultrasounds before and after viewing a web-based e-learning module[11]. Cuca *et al.* tested an e-learning program for lung ultrasound[12]. The results of a multiple choice questionnaire about the basics of lung ultrasound before and after the completion of the e-learning were compared with the results of the questionnaire after a one-day custom classroom training. Both studies found that e-learning is highly effective in the improvement of image recognition, e-learning results equalled results of classroom-based training[11,12].

E-learning is a new way of learning and requires a more active approach of the student to acquire knowledge and skills than traditional types of education. An active attitude combined with the ability to choose the moment of participation, may have the potential to improve learning efficiency. Wutoh *et al.* reviewed the effect of interventions with internet-based continuing medical education on the performance of physicians and health care outcomes[13]. The results demonstrated that internet-based continuing medical education programs are just as effective in imparting knowledge as traditional formats of continuing medical education. Other reviews and meta-analysis have similar conclusions[14].

The strength of this study is that it explored the effect of e-learning in a setting of daily routine ultrasonography. The images were blindly assessed by the supervisors, who used a validated quality instrument with a good inter-observer score. A limitation of the study is the potential selection bias: the self-initiation of performing an e-learning module might select better sonographers. A second limitation is that the images of the control group were selected from a database, to prevent the control group from improving their skills because they would know that their images were being investigated. However, in this design the comparability of the groups cannot be fully determined. The groups were made as comparable as possible by choosing images from a database, made by sonographers with the same level of education as the CLEM participants. Therefore the results have to be interpreted with the knowledge of these limitations.

The purpose of the CLEM was to enhance knowledge and skills for anyone who appreciated it, free access on internet and the immediate broad usage made randomization impossible.
In conclusion, an e-learning course might be an appropriate way to train experienced sonographers for the skill of ultrasonographic cervical length measurement. To further investigate the effect of e-learning on the quality of ultrasound images more research and the use of other study designs may be necessary.

Statement of contribution

MO wrote the first draft of the paper. MO, PB, MH were involved in the construction of the e-learning module. AJ, EP, CG, BM, MH critically revised the manuscript for important intellectual content. All authors approved of the final version of the manuscript to be submitted.

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