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Hybrid Simulation in Teaching Clinical Breast Examination to Medical Students

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Abstract Clinical breast examination (CBE) is traditionally taught to third-year medical students using a lecture and a tabletop breast model. The opportunity to clinically practice CBE depends on patient availability and willingness to be examined by students, especially in culturally sensitive environments. We propose the use of a hybrid simulation model consisting of a standardized patient (SP) wearing a silicone breast simulator jacket and hypothesize that this, compared to traditional teaching methods, would result in improved learning. Consenting third-year medical students (N = 82) at a university-affiliated tertiary care center were cluster-randomized into two groups: hybrid simulation (breast jacket + SP) and control (tabletop breast model). Students received the standard lecture by instructors blinded to the randomization, followed by randomization group-based learning and practice sessions. Two weeks later, participants were assessed in an Objective Structured Clinical Examination (OSCE), which included three stations with SPs blinded to the intervention. The SPs graded the students on CBE completeness, and students completed a self-assessment of their performance and confidence during the examination. CBE completeness scores did not differ between the two groups (p = 0.889). Hybrid simulation improved lesion identification grades ($p < 0.001$) without increasing false positives. Hybrid simulation relieved the fear of missing a lesion on CBE (p = 0.043) and increased satisfaction with the teaching method among students (p = 0.002). As a novel educational tool, hybrid simulation improves the sensitivity of CBE performed by medical students without affecting its specificity. Hybrid simulation may play a role in increasing the confidence of medical students during CBE.

Keywords Clinical breast examination · Simulation · Medical education

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Introduction

Breast cancer remains the most common cancer among women worldwide [1]. Globally, preventive efforts such as raising awareness and advocating for regular breast examinations are aimed towards early detection. Clinical breast examination (CBE) is extensively practiced in countries like the USA and is considered part of the regular health exam [2]. Although the evidence to support the benefit of breast examination in terms of reducing breast cancer morbidity and mortality via early breast cancer detection is not well established [2], CBE remains a basic required skill for physicians in training and offers healthcare providers the opportunity to educate women on breast health.

According to the American College of Surgeons, overcoming the barriers to CBE performance starts with proper training. Didactic presentations, visual demonstrations, and practical sessions that provide feedback all constitute the components of proper training [2]. Even standardized patients alone have proven efficacious in instructing CBE to healthcare providers [3, 4]; other studies have shown that simulators could have a role in relieving performance anxiety among physicians in training [5]. A study on the pelvic examination simulation model found that the addition of standardized patient, albeit separately from the participants' interaction with the simulator, improved learning outcomes [6]. Additionally, two independent trials found that CBE simulators produced significant gains in clinical breast examination skills suggesting that this technology may improve the accuracy and quality of breast cancer screening [7].

Our goal in this paper is to study *hybrid simulation* as a tool for teaching CBE to medical students by incorporating a patient actress, i.e., a trained, standardized patient, wearing a breast simulator jacket. We hypothesize that the combination of breast simulators and standardized patients in a single encounter is an effective method for teaching CBE, particularly in terms of lesion detection and identification.

Materials and Methods

This is a randomized controlled blinded behavioral trial aiming at assessing the efficacy of hybrid simulation of CBE as an educational tool. It was approved by the Institutional Review Board (IRB) at the American University of Beirut.

All study processes, including the lecture, the practical sessions and the Objective Structured Clinical Examination (OSCE) took place within the Department of Obstetrics and Gynecology (OBGYN) of the American University of Beirut Medical Center (AUBMC). The participants represented a convenient sample of all third-year medical students attending the aforementioned university; the only exclusion was past experience in performing CBEs, which none of the participants had performed before.

Procedures

Overview (see Fig. 1)

As the didactic portion of the intervention is a core requirement of third-year medical students, all future participants were notified of the lecture per the usual administrative channels. The lecture on breast pathology and examination was given by JN (one of the investigators), followed by tutorial videos on the technique of CBE (1 h total) [8] as well as principles and tips for culturally-sensitive communication skills (15–20 min). Following the lecture, all third-year medical students who attended were group-randomized into the hybrid simulation arm or the control arm. In the next 2 weeks, both groups had separate practical sessions lasting up to 1 h with JN during which they received guidance and feedback on carrying out a CBE. Learning objectives of the practical sessions were explicitly outlined and distributed to the students ahead of time (supplemental material, Table 1Sa). The control group was practiced using a low fidelity breast simulator consisting of a tabletop breast model (MammaCare), while the hybrid simulation practicum consisted of a clinical breast examination of a standardized patient wearing a breast simulator jacket from Limbs & Things (Bristol, UK). The feedback given to both groups was based on a grading rubric that will later be used by the SPs during the assessment 2 weeks later (supplemental material, Table 1Sb). In both training models, the lesions presented were of fibrocystic diseases and carcinomas. Each of the students got to perform a full CBE during these practicums. It is worth noting that although the traditional tabletop model does not offer as comprehensive an assessment of the topography of lesions as practice on an SP wearing a breast jacket would, nevertheless, the consistency and textural integrity of the lesion descriptions remain highly reliable. Therefore, the randomization does not play a significant role in tipping the advantage towards the intervention group. After the sessions, students answered a survey regarding their satisfaction with the teaching activities including the lecture, video, and practical sessions. In the 2 weeks between practice and assessment, the two groups rotated together in the OBGYN department and saw patients in the inpatient and outpatient settings and in the operating room. None of the students got a chance to witness or perform a CBE on a patient during that time period.

Randomization

The 90 students had been previously divided, as part of the curriculum, into six random rotation groups of 15. As part of this study, the groups themselves were then randomized as clusters into the hybrid simulation arm or the control arm. Group randomization (or cluster randomization) was adopted, not only because the rotation groups were administratively convenient and a priori adequately randomized but also for the following methodological reasons. The didactic interventions, namely lectures and simulation laboratory sessions, are naturally delivered to groups of learners rather than single individuals. When applied to individuals who readily interact within a pre-formed group, such didactic interventions are likely to "leak" or spread within the group [9]. Peer effects are also likely to occur when an individual's behavior—such as compliance, attitude, or response—is affected by the changes in behaviors of other individuals within the group. Such potential group contaminations were avoided through the use of group randomization.

Fig. 1 Overview: study timeline

2 weeks

Lecture followed by Randomization | Practicums (Control Group: Table-top Model; Intervention Group: SP + Breast Jacket) | OSCE

Group allocation

The intervention to control allocation ratio was 2:1. In the design phase of the study, the total sample size had been set as 90 based on the maximum number of third-year students that could be recruited. However, since sample size and power calculations required an estimation of the effect but was not available at the beginning of the study, the ratio was arbitrarily set to 1:1. Later, the expected difference in the primary outcome of lesion identification between groups was estimated from an interim analysis. As previously reported, it was based on the first 42 participants [10]. Based on a sample size calculation for a conservative 85% power, in order to detect the estimated expected effect, a ratio of 2:1 or 1:2 would be sufficient. Otherwise, a ratio of 1:1 would give more power than necessary, while a ratio of 1:2 would involve a larger number of students being denied the new intervention. While the old teaching methods were not unethical, a ratio of 2:1 constituted a more ethical choice and was adopted for randomization throughout the remainder of the study.

Study Outcomes

The primary outcomes of CBE proficiency were *CBE completeness* and *lesion identification.* Secondary outcomes included self-reported performance and attitude during the CBE OSCE, including the student's reported unease during CBE and its perceived causes. Assessment of outcomes took place 2 weeks after the educational activities through an OSCE-like setting that did not contribute to the students' evaluation outside of the study. The OSCE consisted of three stations with three SPs.

Standardized Patients

Although the use of SPs for teaching, assessment, and research purposes is widespread, in order for readers to judge the quality of research and the validity of findings, specific standards for reporting SP use in research have been developed [11]. This study followed the categorization of Howely et al. with regard to the SPs:

a. SP characteristics and training:

   In our study, the three SPs, blinded to student randomization, represented middle-aged women seen in the Lebanese society. The SPs were trained by the investigators (JN, AKS, and SN) on (1) their individual role in each station, (2) how to assess breast palpation on the simulator jacket, and (3) how to fill the grading rubric on CBE completeness. Six training sessions, each lasting a few hours, were performed for the duration of 2 weeks. During the OSCEs, another rater (SN) randomly audited the sessions and the grading process to assess consistency in routine across stations and with different students.

b. Encounter characteristics:

   The SP in each station was equipped with a breast simulator jacket. The SP was consented to CBE only if the participating student asked for her permission to proceed to the CBE. The estimated encounter time in each station was approximately 15 min.

Measures and Variables

At the end of each encounter, the SP graded the participant's CBE performance by filling out a checklist on *CBE completeness*. The checklist included items on the technique of the examination, both its *visual inspection* and *palpation* components. CBE performance scores were calculated by summing the individual items on the SP's scoring checklist for each encounter (supplemental material, Table 1Sb). The participating medical student also filled out an in-clinic note and a self-reported performance survey. The note addressed items pertaining to their findings during the CBE, and it helped assess for *lesion identification.* The in-clinic note was later graded by AKS who was also blinded to participant randomization. Numerical measures of outcomes consisted of scores and grades averaged from all three OSCE stations for each student.

Statistical analysis was done by a researcher blinded to the study arms and using SPSS 20.0 from IBM (Armonk, New York, USA). Normal distribution of scores was rejected by the Shapiro-Wilk test. Accordingly, scores were reported as medians and ranges. Distributions were compared using the Mann-Whitney *U* test. Mean ranks are reported only to indicate the direction of the effect when the distributions are significantly different ($p < 0.05$).

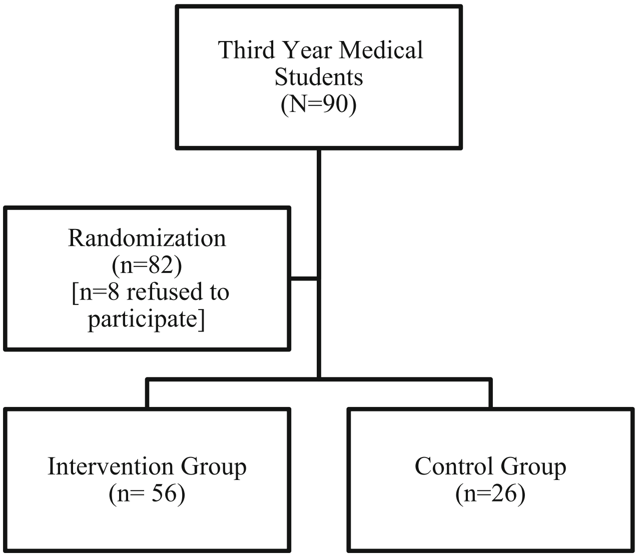

Fig. 2 Population distribution

Results and Discussion

As participants were randomized by a 2:1 ratio, there were 56 students in the hybrid simulation group and 26 in the control group (see Fig. 2); both arms had a relatively even gender distribution, with 50 and 46.2% being male respectively (Pearson's chi-square *p* value = 0.747).

Items graded for the participating student's performance and proficiency were averaged from all three OSCE stations, and each item was given a weight point for its contribution to the composite scores of *CBE completeness*, *visual inspection*, *palpation*, and *lesion identification*. Our results show that hybrid simulation and the traditional teaching method were not significantly different in terms of overall *CBE completeness* ($p = 0.889$), including the *visual inspection* ($p = 0.996$) and *palpation* ($p = 0.885$) aspects of the examination (see Table 1). However, as hypothesized, hybrid simulation was associated with a significantly higher *lesion identification grade* ($p < 0.001$), specifically in *lesion reporting*, *identification of malignant features*, and *accurate location identification* as compared to the traditional teaching method (see Table 2).

Compared to the control group, students in the hybrid simulation group agreed more on three of the satisfaction survey items (see Table 3):

(1) They were more likely to recommend hybrid simulation for teaching CBE as a regular part of the medical school curriculum ($p = 0.004$).
(2) The hybrid simulation teaching activity helped develop confidence in the clinical setting ($p = 0.017$).
(3) The intervention helped in better integration of theory and practice ($p = 0.029$).

These three items drove the composite score of satisfaction with the teaching activity to be significantly higher with hybrid simulation than with the control teaching activity ($p = 0.002$). Based on these results, the use of hybrid simulation in teaching CBE to medical students could yield improved proficiency in performing the examination and lesion identification and increase the students' confidence level when performing a CBE.

No statistically significant differences between the two groups were observed in the distributions of self-reported communication efficacy and comfort during the OSCE ($p = 0.346$ and $p = 0.172$, respectively). Also, the score for causes of unease during CBE ($p = 0.249$) as well as the proportions of single individual causes of unease were numerically lower in the hybrid simulation group (see Table 4).

Lesion identification had been previously proven to be similar in students who learned on standardized patients (real breast tissue) and those who learned on a simulated model [12]. In that regard, we found that combining both modalities, by employing hybrid simulation, resulted in a cumulative augmented effect on lesion identification skills. Hybrid simulation had an added value over low-fidelity simulation and non-guaranteed real patient encounters. Despite the fact that hybrid simulation improved the sensitivity of detecting and the accuracy of identifying a lesion, the rate of false positive findings did not increase from that of the control group. Accordingly, our findings also implied that the specificity of the CBE is not negatively affected by hybrid simulation.

In terms of the students' self-reported attitude, students who learned CBE in a hybrid simulation setting tended to feel more comfortable while performing CBE. This finding is

Table 1 Performance scores for CBE completeness

	Hybrid simulation ($N = 56$)	Control ($N = 26$)	*p* value[a]
CBE completeness score	16.58 (7.33; 19.00) [41.25]	16.83 (9.33; 19.67) [42.04]	0.889
Visual inspection score	5.00 (0.33; 6.00) [41.49]	4.83 (2.33; 6.00) [41.52]	0.996
Palpation score	11.50 (6.00; 13.33) [41.24]	11.67 (6.67; 13.67) [42.06]	0.885

Whenever the distributions are significantly different in the Mann-Whitney *U* test, the mean rank values would indicate the direction of the effect. Level of significance is 0.05

[a] The scores are reported as median (range) and [mean rank]

Table 2 Lesion identification grade and its six constituents

	Hybrid simulation (*N* = 56)	Control (*N* = 26)	*p* value[a]
Lesion identification grade	3.00 (0.00; 5.33) [51.35]	1.00 (− 1.00; 3.33) [20.29]	< 0.001
Reporting a lesion	1.00 (0.00; 1.00) [49.19]	0.50 (0.00; 1.00) [24.94]	< 0.001
Malignant features of the lesion	0.67 (0.00; 2.00) [49.20]	0.00 (0.00; 1.00) [24.92]	< 0.001
Accurate location of the lesion	1.33 (0.00; 2.00) [52.45]	0.33 (0.00; 1.00) [17.92]	< 0.001
Falsely reporting a lesion	0.00 (− 0.67; 0.00) [43.25]	0.00 (− 1.00; 0.00) [37.73]	0.250
Detecting lymph nodes	1.00 (0.00; 2.00) [42.21]	1.00 (0.00; 2.00) [39.96]	0.651
Falsely reporting lymph nodes	0.00 (− 0.67; 0.00) [40.27]	0.00 (− 0.67; 0.00) [44.15]	0.306

Whenever the distributions are significantly different in the Mann-Whitney *U* test, the mean rank values would indicate the direction of the effect. Level of significance is 0.05

[a] The scores are reported as median (range) and [mean rank]

paralleled by a tendency towards smaller proportions of CBE-related fears in the hybrid simulation group. With hybrid simulation, the tendency towards more ease and comfort as perceived by the student suggests that this teaching method could boost the students' confidence in their ability to communicate with their patients during CBE. A major cause of CBE-related discomfort in medical students had been found to be the fear of missing a lesion on a real patient [5]. Interestingly, in our study, this anxiety was similarly the only cause of unease and it was actually relieved by the introduction of hybrid simulation as a teaching tool.

In line with our findings, it had been previously shown that the use of simulators in teaching CBE, in addition to lectures, improved satisfaction among teachers and students [13]. The hybrid simulation participants' recommendation to adopt this method in the medical school curriculum reflects higher appreciation of the value of the practical teaching session of CBE for students who learned using the hybrid simulation model as opposed to those who learned on a tabletop model.

Limitations

We do not believe that practicing on the breast jacket could have given the medical student an advantage in lesion identification over the control group, as previous studies in simulation have shown [14].The sample size might have not been sufficient to detect effects at the level of certain variables that were not specified as primary outcomes of interest for this study. Accordingly, the small number of study subjects might explain the failure to find statistically significant differences in some of the measures, despite an inclination to effects in the same direction in parallel measurements such as comfort and unease. This warrants the need for further investigations that are adequately powered to target these variables and explore other factors that affect didactic efficacy of simulation tools. Although female and male students were equally distributed in both groups, another limitation could have been the medical student gender and the possible fact that female students are more at ease conducting a CBE on another woman.

Table 3 Participating students' satisfaction with the teaching activity

	Hybrid simulation (*N* = 56)	Control (*N* = 26)	*p* value[a]
Satisfaction with teaching activity[b]	3 (0; 9) [47.67]	2 (0; 8) [29.58]	*0.002*
Was a worthwhile use of my time	20.37% (11)	19.23% (5)	1.000
Had no added value to the learning experience (inverted)	89.29% (50)	84.62% (22)	0.718
Did not help me develop confidence in clinic (inverted)	87.50% (49)	61.54% (16)	*0.017*
Constituted a valuable learning experience	16.67% (9)	3.85% (1)	0.154
Provided a chance to learn in a safe environment	31.48% (17)	15.38% (4)	0.177
Was realistic	18.52% (10)	11.54% (3)	0.531
Was effective in helping me integrate theory and practice	24.07% (13)	3.85% (1)	*0.029*
Should become a regular part of the curriculum	57.41% (31)	23.08% (6)	*0.004*
I feel more prepared for my upcoming CBE	11.11% (6)	3.85% (1)	0.418

[a] Fisher's exact test was used to compare the frequencies for the individual items and the Mann-Whitney *U* test for the distributions of the composite score. Level of significance is 0.05

[b] The composite score is calculated from the sum of the set of individual binary items beneath and is reported as median (range) and [mean rank]. The distributions are significantly different in the Mann-Whitney *U* test, and the mean rank values indicate the direction of the effect

Table 4 Participating students' self-reported performance and attitude during the CBE/OSCE activity

	Hybrid simulation (*N* = 56)	Control (*N* = 26)	*p* value[b]
Self-reported communication score[a,c]	3 (0; 8) [43.16]	2 (0; 8) [37.92]	0.346
Effective communication[a]	32.14% (18)	34.62% (9)	1.000
Understanding patient's disclosure[a]	50.00% (28)	34.62% (9)	0.237
Understanding patient's behavior[a]	51.79% (29)	38.46% (10)	0.343
Awareness of cultural differences[a]	50.00% (28)	42.31% (11)	0.636
Control over attitude[a]	51.79% (29)	42.31% (11)	0.482
Examination without prejudice[a]	35.71% (20)	38.46% (10)	0.811
Attitude without prejudice[a]	39.29% (22)	42.31% (11)	0.813
Adjustment of behavior[a]	35.71% (20)	30.77% (8)	0.804
Comfort during OSCE[c]	1 (0; 5) [43.77]	0 (0; 5) [36.62]	0.172
Overall CBE	39.29% (22)	23.08% (6)	0.212
During visual inspection	37.50% (21)	34.62% (9)	1.000
During eliciting nipple discharge	37.50% (21)	23.08% (6)	0.219
During detecting abnormalities	32.14% (18)	15.38% (4)	0.180
With level of knowledge and experience	26.79% (15)	15.38% (4)	0.399
Unease during CBE[c]	2 (0; 6) [39.46]	2 (0; 8) [45.88]	0.249
Fear of missing a lesion	23.21% (13)	46.15% (12)	*0.043*
Intimate nature of CBE	42.86% (24)	53.85% (14)	0.476
Fear of causing harm or pain	23.21% (13)	19.23% (5)	0.780
Due to nipple and areola palpation	30.36% (17)	19.23% (5)	0.423
Trying to communicate effectively	41.07% (23)	61.54% (16)	1.000
General performance anxiety	41.07% (23)	53.85% (14)	0.343
Cultural dissimilarity	7.14% (4)	11.54% (3)	0.673
Other sources of fear	5.36% (3)	3.85% (1)	1.000
No anxieties during CBE	7.14% (4)	7.69% (2)	1.000

[a] These items summarize the student's answers on self-reported surveys from all three stations

[b] Fisher's exact test was used to compare the frequencies for the individual items and the Mann-Whitney *U* test for the distributions of the composite scores. Level of significance is 0.05

[c] Composite scores are calculated from the sum of the set of individual items beneath, and are reported as median (range) and [mean rank]. Whenever the distributions are significantly different in the Mann-Whitney *U* test, the mean rank values would indicate the direction of the effect

The cultural background of the students was also not assessed. Although the cultural background of the SP's was addressed through training, that of the medical students could not be controlled except with randomization.

Further studies ought to be designed to specifically test for the secondary outcome of the potentially distracting effect of cultural background, i.e., whether religiousness or liberalism of the patient interferes with the ability of the medical student to detect the same lesion in different patients. We recommend the implementation of such hybrid simulation in the curriculum of the third-year medical students at the American University of Beirut (Lebanon). We also recommend the use of hybrid simulation in other settings where a more realistic simulation needs to be integrated and in settings where confidence of medical students needs to be encouraged.

Conclusion

Hybrid simulation is a new method that employs the use of standardized patients and breast model jackets to teach CBE. The findings of this study were congruent with previous studies in CBE simulation but added the following: hybrid simulation leads to an important improvement in the capacity of medical students to correctly identify a lesion and provide an accurate description of its location and malignant potential. It also increases their confidence during CBE. Although hybrid simulation might not provide an advantage over the traditional method in terms of CBE completeness, it may increase CBE sensitivity (the whole goal of a screening examination) without affecting its specificity.

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Compliance with Ethical Standards This is a randomized controlled blinded behavioral trial aiming at assessing the efficacy of hybrid simulation of CBE as an educational tool. It was approved by the Institutional Review Board (IRB) at the American University of Beirut.

Conflict of Interest The authors declare that they have no conflict of interest.

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