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ORIGINAL

Medio didáctico para nodulectomía de mama

Educational tool for breast nodulectomy

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ABSTRACT

Introduction: Nodulectomy is an essential procedure in the diagnosis and treatment of breast pathology. In Cuba, the economic constraints limit access to commercial surgical simulators, hindering the development of practical skills among medical students. The objective was to develop and validate a low-cost, recyclable-material teaching aid for breast lumpectomy training. Methods: A technological development study was conducted in three phases: 1) Construction of the simulator using recycled and low-cost materials (cardboard, sponge, foam rubber, among others), incorporating nodules of varying consistency and a color-coding system for histological differentiation; 2) Validation by a panel of 5 experts using a Likert scale to assess realism and relevance; 3) Evaluation by 20 undergraduate students who rated its usefulness and overall satisfaction. Results: The simulator cost 0.50 USD, representing a 99.9% reduction compared to commercial alternatives (>700 USD). Expert validation yielded an overall mean score of 4.3/5, with "teaching utility" receiving the highest rating (4.6/5). All students (100%) found it useful for understanding the surgical technique and developing palpation skills, and 85% rated their satisfaction as very high. Conclusions: The developed teaching aid is valid, functional, and economically viable for breast lumpectomy training, demonstrating that innovation with local resources can overcome technological shortages and enhance medical education.

Keywords: medical education; breast; teaching materials; breast neoplasms.

RESUMEN

Introducción: La nodulectomía es un procedimiento esencial en el diagnóstico y tratamiento de la patología mamaria. En Cuba, las limitaciones económicas dificultan el acceso a simuladores quirúrgicos comerciales, lo que afecta el desarrollo de habilidades prácticas en estudiantes de ciencias médicas. El objetivo fue desarrollar y validar un medio didáctico de bajo costo y material reciclable para la enseñanza de la nodulectomía de mama. Métodos: Estudio de desarrollo tecnológico en tres fases: 1) Construcción del simulador con materiales reciclados y de bajo costo (cartón, esponja, foami, entre otros), incorporando nódulos de consistencia variable y un código de colores para su diferenciación histológica; 2) Validación por panel de 5 expertos mediante una escala de Likert para evaluar realismo y pertinencia; 3) Evaluación por 20 estudiantes de pregrado que calificaron su utilidad y satisfacción global. Resultados: El simulador tuvo un costo de 0.50 USD, lo que representa una reducción del 99.9% respecto a alternativas comerciales (>700 USD). La validación por expertos obtuvo una puntuación media global de 4.3/5, destacando la "utilidad para la enseñanza" (4.6/5). El 100% de los estudiantes lo consideró útil para comprender la técnica quirúrgica y desarrollar habilidades de palpación, y el 85% calificó su satisfacción como muy alta. Conclusiones: El medio didáctico desarrollado es válido, funcional y económicamente viable para la enseñanza de la nodulectomía de mama, demostrando que la innovación con recursos locales puede suplir carencias tecnológicas y potenciar la formación médica.

Palabras clave: educación médica; mama; materiales de enseñanza; neoplasias de la mama.

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INTRODUCTION

The breast nodule is among the most frequent clinical concerns in gynecological and mastological consultation. It is defined as a mass or focal protuberance within the breast tissue that differs in consistency from the surrounding tissue. (1) Worldwide, it is estimated that 1 in 8 women will develop some type of breast abnormality requiring intervention during their lifetime. (2)

Although 80% of excised nodules turn out to be benign, nodulectomy is the cornerstone for the early detection of breast cancer, which represents the leading cause of cancer mortality in women worldwide. (3) In Cuba, the management of the breast nodule is a public health priority within the National Program for Early Diagnosis of Breast Cancer; this cancer is the leading cause of incidence and the second cause of cancer death in Cuban women. This generates a high volume of annual nodulectomies as a control and treatment measure. (4)

The bibliometric analysis by Flores-Cohaila (5) identified general surgery as the specialty with the highest production in economic simulation (27 % of the studies), followed by obstetrics and gynecology (14,5 %). In Cuba, the teaching-educational process in medical sciences requires resources and supplies that allow the student to develop the practical skills essential for their comprehensive training. (6)

In response to this need, the objective is to present a didactic tool for breast nodulectomy, which was developed from recyclable materials, with no significant economic cost, quick to make, reusable, and with a long useful life. Its implementation could strengthen techniques and knowledge in subjects such as Human Anatomy, Clinical Propaedeutics, Internal Medicine, Obstetrics and Gynecology, and General Surgery, while promoting values of environmental care and resilience.

METHODS

1 study of technological development and innovation was conducted at the Faculty of Medicine No. 2 of Santiago de Cuba. The project was structured in 3 phases: 1) construction of the didactic medium; 2) validation by experts; and 3) evaluation by students.

Phase 1: Development and Construction of the Model

For the construction of the simulator, low-cost and recyclable materials were used, selected to replicate the anatomy of the chest wall and breast: cardboard base (25 x 25 cm), top part of a plastic bottle, two types of sponge (porous and high-density), skin-colored foam sheet (EVA rubber), red and blue yarn, silicone glue, and elements to simulate nodules (tamarind seeds, small sea stones, ball bearings, and deodorant pearls). Paint or colored pencils were used for details.

Base and support: The top of a plastic bottle was fixed onto a cardboard base of 25 x 25 cm, using glue and yarn as reinforcement, to simulate the chest wall.

Breast tissue: A circular sponge layer was adhered onto the plastic support.

- Nodule simulation: Small spherical structures were created with silicone or the aforementioned elements were used. For didactic differentiation, a color code was implemented: malignant tumors were marked with red yarn or a red dot, while benign ones were identified with blue color.

- Positioning and depth: The nodules were adhered to the first layer of sponge, distributing them in different quadrants. Subsequently, they were covered with a second layer of sponge, varying its thickness to simulate different depths of location.

- Skin and external details: The entire assembly was covered with a skin-colored foam sheet, fixing it along the edges. The areola and nipple were made from the same material. On the reverse side of the cardboard base, representative histological images of benign and malignant tumors were adhered, associating them with the distinctive colors to reinforce the anatomoclinical correlation.

Phase 2: Expert Validation

A panel of 5 experts was selected through purposive sampling, with the following inclusion criteria: being a specialist in General Surgery or Obstetrics and Gynecology, having a master's degree in Medical Education, having more than 5 years of clinical and teaching experience, and being involved in undergraduate and postgraduate training. An evaluation instrument with 5 items, assessed using a Likert scale from 1 (Strongly disagree) to 5 (Strongly agree), was designed to evaluate: 1) Realism of breast anatomy, 2) Realism of nodule consistencies, 3) Usefulness for teaching the nodulectomy technique, 4) Relevance of the color code as a didactic tool, and 5) Global assessment of the model. An additional qualitative evaluation of positive aspects and aspects to

improve was requested.

Phase 3: Student Evaluation

An evaluation pilot was conducted with 15 undergraduate students of the Medicine program. After a supervised practical session with the didactic medium, in which they performed palpation and identification of nodules, and the steps of nodulectomy, an anonymous survey of perceived usefulness was applied. The survey included questions with a 5-point Likert scale on the ease of identifying nodules, the usefulness for understanding the surgical technique, and overall satisfaction with the medium.

Data were processed in Microsoft Excel 2016. Frequencies, percentages, means, and standard deviations were calculated. The study was approved by the Ethics Committee of the Faculty of Medicine No. 2. All participants (experts and students) signed informed consent. Anonymity and confidentiality of the data were guaranteed.

RESULTS

A reusable and reproducible breast simulator was developed (Figures 1-3). The total production cost was 250 Cuban pesos (0.50 USD), of which the foam sheet accounted for the largest expense (150 CUP). In comparison, commercial simulators for similar procedures cost more than 700 USD on the international market, which represents a 99.9% cost reduction. The estimated production time was 45-60 minutes.

Figure 1. Top view of the simulator.

The overall mean score assigned by the expert panel was 4.3 out of 5 (SD ± 0.4). The highest-rated item was its usefulness for teaching the nodulectomy technique, with a mean of 4.6 out of 5, followed by the relevance of the color code at 4.4 out of 5. The realism of the anatomy received the lowest score at 3.8 out of 5 and was noted in the qualitative comments as acceptable for the teaching objective, although improvable in final skin texture.

100% (n=15) of the students rated the simulator as useful or very useful for developing palpation skills and for understanding the surgical technique of nodulectomy (Figures 4 and 5). In the assessment of overall satisfaction, 80% (n=12) rated it as very high and 20% (n=3) as high. Comments highlighted the possibility of practicing without risk and its usefulness for memorizing the correlation between palpation and the histological image on the reverse side.

Figure 2. Lateral view of the simulator.

Figure 3. Bottom view of the simulator.

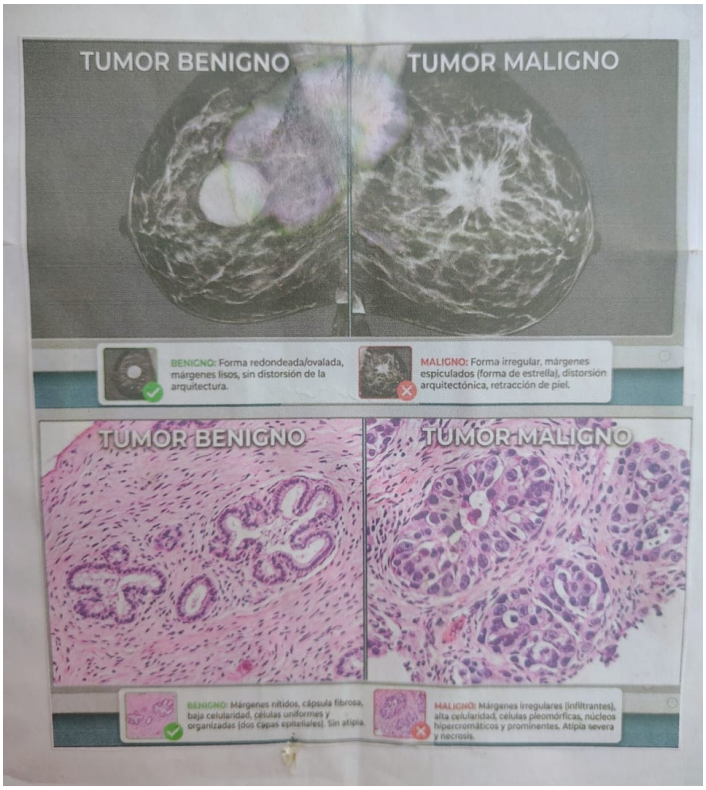

Figure 4. Evaluation process by students.

Figure 5. Student evaluation process.

DISCUSSION

Breast nodules or tumors, depending on their nature, can range from simple cysts and benign fibroadenomas to invasive carcinomas, making their study a diagnostic priority (4). Nodulectomy in the breast context has a diagnostic and therapeutic objective; hence its cognitive importance.

The educational tool presented here demonstrates the feasibility of developing a breast nodulectomy simulator at a production cost of 250 Cuban pesos (0.50 USD). This figure contrasts markedly with the prices of available commercial simulators. Careta et al. (7) describe the construction of low-cost simulators for breast procedures guided by ultrasound and stereotactic mam-

mography, with an approximate cost of $3.45 USD. Hey et al. (8) report a gelatin-based model for breast biopsy in Rwanda whose low cost permits implementation in low-income settings. Even compared with these low-cost alternatives, the simulator presented here represents an additional significant reduction.

The overall mean score assigned by the expert panel is consistent with the findings of Özdemir et al. (9), who reported that breast self-examination training using hybrid simulation significantly improved knowledge, skills, and the ability to correctly evaluate pathological findings in nursing students. Anatomical realism received the lowest score and was noted in qualitative comments as acceptable for the teaching objective, although improvable in final skin texture. This discrepancy is a recurring pattern, indicating that partial realism may be sufficient for specific educational objectives.

100% of the students rated the simulator as useful or very useful for developing skills, a finding consistent with that reported by Jana et al. (10), who reported that correct sampling improved from 75.7% to 91.4% after training and that biopsy adequacy increased from 68.5% to 85.7%. This supports the notion that low-cost simulators can produce substantial improvements in procedural skills and student confidence.

The main strength of this work lies in its resilient and innovative approach, transforming waste into a valuable educational resource. The integration of a color code linked to histological images is an educational contribution that goes beyond simple mechanical training, fostering clinical reasoning. The limitation of the study is the small validation sample; therefore, the results are preliminary and cannot be generalized without larger studies. Future work includes objective measurement of skill acquisition using checklists in pre- and post-test evaluations and the application of the “Resiliencia” project to extend the model to other surgical techniques.

CONCLUSIONS

The simulator developed for breast nodulectomy proved to be valid, functional, and economically viable for undergraduate teaching, with potential benefits for more than 5 subjects in the Medicine degree. This project proposes a strategy for effective import substitution, drastic cost reduction, and promotion of environmental care through recycling, reaffirming the commitment to overcoming material adversities.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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