Salud, Ciencia y Tecnología - Serie de Conferencias. 2023; 2:428
doi: 10.56294/sctconf2023428

SERIE DE CONFERENCIAS

Categoría: Congreso Científico de la Fundación Salud, Ciencia y Tecnología 2023

ORIGINAL

Developing clinical decision making in stroke through virtual online simulation: automated asynchronous or instructor-led synchronous feedback? A randomized controlled trial

Desarrollo de la toma de decisiones clínicas en el ictus mediante simulación virtual en línea: ¿Feedback asíncrono automatizado o síncrono dirigido por un instructor? Un ensayo controlado aleatorizado

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Citar como: Fuentes Lombardo V, Palominos Salas J, Pettersen Correa MA, Caro Guerra P, Navia González V, Hoppe A, Armijo-Rivera S, Machuca-Contreras F. Desarrollo de la toma de decisiones clínicas en el ictus mediante simulación virtual en línea: ¿Feedback asíncrono automatizado o síncrono dirigido por un instructor? Un ensayo controlado aleatorizado. Salud, Ciencia y Tecnología - Serie de Conferencias 2023; 2:428. https://doi.org/10.56294/sctconf2023428

Recibido: 05-06-2023 **Revisado:** 01-08-2023 **Aceptado:** 03-10-2023 **Publicado:** 04-10-2023

ABSTRACT

Aim: to determine whether asynchronous virtual simulation with automatic feedback enhances learning about clinical decision-making in stroke compared with synchronous simulation with instructor-guided feedback in 4th-year medical students. We hypothesize that instructor-guided feedback drives better learning than automatic feedback.
Methodology: a quantitative randomized controlled parallel study was designed using the CONSORT extension to simulation studies. Twenty 4th year undergraduate medical students were divided into two groups. One group performed virtual simulations with instructor-guided feedback, and the other worked autonomously with automatic feedback. We administered a knowledge score test survey before and after applying the intervention bundle and a usefulness perception survey. Two-way repeated measures analysis of variance (ANOVA) was used to compare changes in performance.
Results: the results of the two-way ANOVA on the performance level showed no significant changes between groups and between the first and third scenarios (p=0,428). Analysis of the simple main effect showed no significant difference between groups in the post-test (p =0,086) and no significant difference after the third scenario in the Synchronous (p = 0,001) and Asynchronous (p = 0,009) groups. The most remarkable improvement was the International Normalized Ratio that contraindicates thrombolysis (70 % improvement), followed by the first-line drug for hypertension and the platelet value that contraindicates thrombolysis (25 % improvement for both).

Conclusion: we did not identify differences in student stroke knowledge gained via virtual simulation with automated v/s instructor-guided feedback. The students learned specific elements linked to the safety of administering thrombolytics in patients with stroke.

Keywords: Stroke; Medical Education; Clinical Competence; Simulation Training; Virtual Simulation; Formative Feedback.

RESUMEN

Objetivo: determinar si la simulación virtual asíncrona con retroalimentación automática mejora el aprendizaje sobre la toma de decisiones clínicas en el ictus en comparación con la simulación síncrona con retroalimentación guiada por el instructor en estudiantes de medicina de 4º curso. Nuestra hipótesis es que la retroalimentación guiada por el instructor conduce a un mejor aprendizaje que la retroalimentación automática.
Métodos: se diseñó un estudio cuantitativo aleatorizado controlado paralelo utilizando la extensión CONSORT para estudios de simulación. Veinte estudiantes de medicina de 4º curso se dividieron en dos grupos. Un grupo realizó simulaciones virtuales con feedback guiado por el instructor y el otro trabajó de forma autónoma con feedback automático. Se administró una encuesta de puntuación de conocimientos antes y después de aplicar el paquete de intervención y una encuesta de percepción de utilidad. Se utilizó un análisis de varianza (ANOVA) de medidas repetidas de dos vías para comparar los cambios en el rendimiento.
Resultados: los resultados del ANOVA de dos vías sobre el nivel de rendimiento no mostraron cambios significativos entre los grupos ni entre el primer y el tercer escenario (p = 0,428). El análisis del efecto principal simple no mostró diferencias significativas entre los grupos en la prueba posterior (p = 0,086) ni diferencias significativas después del tercer escenario en los grupos Síncrono (p = 0,001) y Asíncrono (p = 0,009). La mejora más destacable fue la de la razón normalizada internacional que contraindica la trombólisis (mejora del 70 %), seguida del fármaco de primera línea para la hipertensión y el valor de plaquetas que contraindica la trombólisis (mejora del 25 % para ambos).
Conclusiones: no identificamos diferencias en los conocimientos sobre ictus adquiridos por los estudiantes mediante simulación virtual con feedback automatizado v/s guiado por el instructor. Los alumnos aprendieron elementos específicos relacionados con la seguridad de la administración de trombolíticos en pacientes con ictus.

Palabras clave: Accidente Cerebrovascular; Educación Médica; Competencia Clínica; Entrenamiento con Simulación; Simulación Virtual; Retroalimentación Formativa.

INTRODUCTION

Stroke is one of the leading causes of disability and death in Chile and worldwide.[1,2,3,4,5,6,7,8] Delays in treatment are associated with the loss of years of life in patients who could have been treated.[3] Before the COVID-19 pandemic, our institution's teaching of stroke management was based on theoretical classes and supervised clinical practices during the internship. Since 2020, virtual simulators have been incorporated in synchronous and asynchronous modes to promote clinical reasoning, showing positive results regarding learning and satisfaction in 5th-year medical school students.[9,10,11,12]

In the literature, there is a study describing that the domain level of final-year students on the treatment of stroke by thrombolysis was low.[5] Other studies describe that simulation may be an effective educational intervention to teach stroke management.[13,14,15]

Virtual simulators can promote clinical reasoning in medical students [8] and motivate them to learn.[16,17,18,19,20,21,22,23] However, the cognitive load of the virtual simulator can affect learning.[24,25,26,27,28] Instructor-led debriefing has been described as influencing learning achievement using virtual simulators.[29,30,31,32,33] However, there is no evidence comparing the effect of virtual simulators' automatic feedback on learning versus instructor-guided feedback using the same virtual simulators.

On the other hand, some reports compare the effectiveness of high-fidelity and virtual simulation, indicating that more evidence is required to determine it.[34,35,36,37]

Because of the restrictions on clinical practice caused by COVID-19, medical schools replaced traditional training, including simulation, which was considered a tool that can be used to deliver clinical experiences, but with some concerns about the possibility of experiencing the complexity of real situations.[38,39,40,41]

Between simulation strategies implemented, it was an online simulation-based pediatric emergency medicine training intervention, with high levels of satisfaction reported by learners, but with some concerns between 40 % of the faculties about the effectivity of the online simulation compared to on-site simulations.[42,43,44,45,46] Another study on hybrid emergency simulation shows that the online simulation observation with instructor-driven debriefing had the same satisfaction appreciation as on-site simulations.[47,48]

An earlier study suggested that an online virtual simulator may be as effective for learning team skills as standardized patient emergency simulations. This study shows the potential value of virtual learning environments for developing medical students' and resident physicians' team leadership and crisis management skills related to the emergency.[16] During the COVID outbreak, some studies have shown pre-post intervention changes using virtual emergency simulation and automatic feedback or instructor-driven debriefing.[4,17,18]

This study hypothesizes that virtual simulation combined with instructor-guided feedback drives better learning than automatic feedback. The general aim is to compare the learning about clinical decision-making in stroke scenarios in 4th-year medical students after asynchronous virtual simulation with automatic feedback versus synchronous simulation with instructor-guided feedback. The specific aims are a) to quantify the students' knowledge gained after different stroke scenarios after virtual simulation with automatic feedback and instructor-guided feedback and b) to know the students' satisfaction with the simulation's utility in acquiring clinical and theoretical knowledge about stroke.

METHODS

Design

A quantitative, randomized, controlled parallel study designed according to the extension for simulation of the Consort Guide.[19]

Participants

The study was conducted at a private Chilean university in its medical school. The sample was defined with the following inclusion criteria: a) to be a fourth-year medical student taking the subject “Clinical Neurology,” b) to be taking the subject module for the first time, and c) to declare voluntarily and without constraint that they wished to participate in the study. Informed consent and ethics committee approval was obtained (IRB Nº36/2020).

Intervention

The participants practiced three cases independent of the group in which they were randomized.

The first case corresponded to a stroke in a normotensive context without prior anticoagulant use. The second case corresponded to a stroke in a hypertensive patient with previous anticoagulant use, thrombolysis contraindication, and an indication of thrombectomy after blood pressure management. The third case corresponded to a stroke in a hypertensive patient without prior anticoagulant use, contraindication for thrombolysis, and indication for thrombectomy. The scenarios used in each simulation session were designed to increase complexity and were consistent with Chilean stroke management guidelines. (table 1)

The groups were exposed to one of these intervention bundles:

a) First group: three synchronous cases in the Body Interact™ simulator driven remotely through the Zoom™ platform and instructor-guided feedback, provided by an experienced neurologist (10 years of experience).
b) Second group: three asynchronous cases in the Body Interact™ simulator with automatic feedback.

Table 1. Adjusted objectives of simulation cases according to the Chilean stroke management guidelines

Simulation Objectives	Objectives declared in the software	Adjusted objectives
Case 1 Stroke without hypertension or oral anticoagulant therapy	1)Monitor vital signs in acute care. 2) Perform neurological evaluations (NIHSS) 3) Treat stroke with alteplase.	1)Suspected stroke 2)Stroke code Activation 3)NIHSS clinical assessment 4)Imaging study (CT and AngioCT) 5)Indication of thrombolysis (bolus and maintenance) 6)Indication for thrombectomy
Case 2 Stroke with hypertension and oral anticoagulant therapy	1)Monitor vital signs in acute care. 2) Perform neurological evaluations (NIHSS) 3) Blood pressure management in acute stroke. 4) Recognize contraindication of alteplase (rtPA) by early changes in CT.	1)Suspected stroke 2)Stroke Key Activation 3)NIHSS clinical assessment 4)Imaging study (CT and AngioCT) laboratory study 5)Contraindication of thrombolysis 6)Indication for thrombectomy
Case 3 Stroke without hypertension and with oral anticoagulant therapy	1)Monitor vital signs in acute care. 2) Perform neurological evaluations (NIHSS) 3) Blood pressure management in acute stroke. 4)Knowledge of alteplase (rtPA) contraindications	1)Suspected stroke 2)Stroke code Activation 3)NIHSS clinical assessment 4)Assessment of anticoagulation status prior to stroke management 5)Imaging study (CT and AngioCT) 6)Indication of thrombolysis (bolus and maintenance) 7)Indication for thrombectomy

Outcomes

Both groups were administered a knowledge score test survey before and after applying the intervention bundle. At the end of the process, they were also administered a usefulness perception survey of the intervention bundle. Both surveys were supported in Google Forms™. The surveys were designed for this study and have the following characteristics:

a) Theoretical knowledge test survey: it was developed to assess the variation in the level of knowledge. It was constructed with 15 questions on various relevant clinical elements in coping with a patient with a stroke. The questionnaire was created by an experienced neurologist who also had teaching experience. Three neurologists with training in medical education were consulted for expert validation. Kuder Richardson 20 (KR-20) was calculated as a reliability statistic with a value of 0,702 for this sample, demonstrating good internal consistency. The dimensions included in the instrument are: suspected stroke, clinical variables for decision making, utility and importance of the National Institute of Health Stroke Scale (NIHSS), ABCDE approach, important pharmacological history of the patient, mechanical thrombectomy and intravenous thrombolysis, management of acute stroke with hypertension, and imaging tests.
b) Usefulness perception survey: it was applied to know the students' perception of the usefulness of the activity. This instrument, which assessed participants' satisfaction with the intervention bundle, corresponds to a Likert 5. It consisted of eight questions, in which they were asked to indicate the degree of satisfaction from 1 to 5 (being five the highest level of satisfaction) concerning two dimensions: a) the learning achieved in training with the virtual simulator and b) with the organization and implementation of the training.

Study Size, Randomization, and Masking

A purposive convenience sample was achieved with 20 fourth-year medical student volunteers recruited from a universe of 84 (23,8 %).

Using Excel, simple randomization was performed, obtaining two groups. One researcher (AP) performed randomization during the second semester of 2021.

The simulations were implemented between November 1 to 30, 2021.

Due to the characteristics of the intervention, no blind techniques were used in this study, and based on the level of masking, it is classified as an open-label. The study design is represented in figure 1.

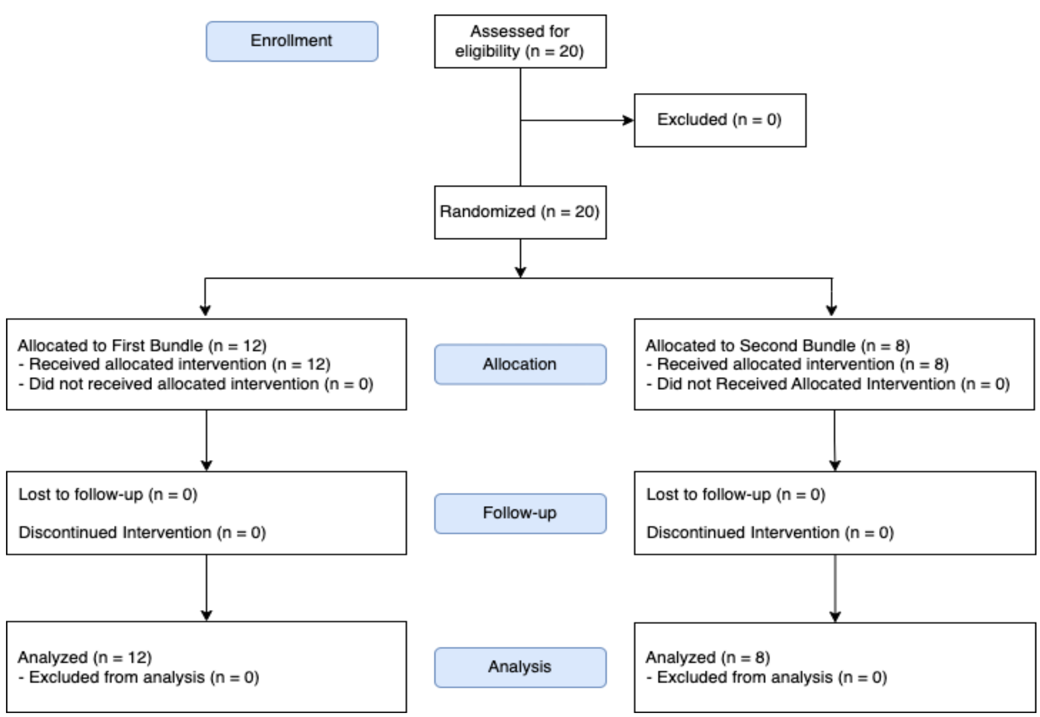

Figure 1. Flow diagram

https://doi.org/10.56294/sctconf2023428

Data analysis

The data were analyzed using Statistical Package for the Social Sciences (SPSS) MAC version 23.0.0.2.

Pre-test knowledge scores for groups were examined using a one-way analysis of variance ANOVA. The paired t-test was used to individually compare the mean differences in knowledge scores for each group (pre and post).

Two-way repeated measures analysis of variance (ANOVA) was used to compare differences between the groups for changes in knowledge score. The effects were tested by examining the interaction effect, using partial eta-squared (η^2) values as a measure of group-by-time effect size. The strength of eta-squared values was interpreted with 0,01 as a small effect, 0,06 as a moderate effect, and 0,14 as a large effect. The level of significance was set at $p<0,05$.[20]

Descriptive analysis using frequency (n), relative importance (%), central tendency (m), and dispersion (sd) statistics were performed to describe participants' perceptions of usefulness.

RESULTS

Knowledge Score Outcomes

There were no significant differences between the groups in pre-test knowledge scores. (Table 2) The mean post-intervention knowledge score is higher in the group with instructor-guided feedback.

The results of the two-way ANOVA on the performance level showed no significant interaction between groups (group 1 v/s group 2) and time (pre-test v/s post-test) (p=0,428). Analysis of simple main effect test results showed no significant difference between the groups in the post-test (p =0,086) and a significant difference over time in the Synchronous (p = 0,001) and Asynchronous (p =0,009) groups (Table 2).

Table 2. Pretest knowledge level by intervention group (synchronous or asynchronous) (n = 20)

					ANOVA	
	n	Mean		DS	F	Sig.
Synchronous	12	11,83	±	2,368	2,725	0,116
Asynchronous	8	10,13	±	2,100		
Total	20	11,15	±	2,368		

The estimated effect size was small ($\eta2 = 0,035$). The aspect with the greatest improvement was the International Normalized Ratio (INR) that contraindicates the use of thrombolysis (70 % improvement), followed by the first-line drug for hypertension and the platelet value that contraindicates thrombolysis (25 % improvement for both) (table 3). The synchronous and asynchronous groups significantly improved the number of correct answers on the post-intervention test, with a p-value of 0,001 and 0,009, respectively (table 4).

Usefulness Perception Outcomes

Regarding the students' perception of the activity, 85 % experienced the maximum level of satisfaction concerning the organization of reasoning and critical thinking, 80 % about the development of capacity decision-making and safe prescription of thrombolysis, and 70 % concerning the development of skills independently. Then, regarding the organization and implementation of stroke training with virtual simulation, 90 % say they have experienced the maximum level of satisfaction with the feedback received by the instructor, 75 % regarding the fact of being able to repeat the cases if they wanted it and about the challenge that solving the cases meant and how this helped to acquire knowledge, 71,4 % regarding an adequate level of complexity and according to the knowledge of a 4th-year student. (figure 2)

https://doi.org/10.56294/sctconf2023428

Table 3: Descriptives of the questionnaire (pre and post-intervention)

Main items of the questionnaire	**Synchronous (n =12)**				**Asynchronous (n = 8)**			
	Before		**After**		**Before**		**After**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
1) Recognition of stroke signs and symptoms	12	100,0	12	100,0	8	100,0	8	100,0
2) Treatment time relevance	11	91,7	12	100,0	8	100,0	7	87,5
3) NIHSS scale utility	5	41,7	8	66,7	6	75,0	7	87,5
4) Priority in ABCDE evaluation	10	83,3	10	83,3	6	75,0	7	87,5
5) Pharmacological history importance	11	91,7	12	100,0	8	100,0	8	100,0
6) Blood pressure relevance in management	12	100,0	12	100,0	8	100,0	8	100,0
7) INR that contraindicates thrombolysis	3	25,0	12	100,0	0	0,0	1	12,5
8) Need for TC before thrombolysis	12	100,0	12	100,0	6	75,0	7	87,5
9) Maximum systolic pressure prior thrombolysis	10	83,3	11	91,7	3	37,5	5	62,5
10) Drug choice for pressure management	9	75,0	12	100,0	2	25,0	6	75,0
11) Time limits for thrombolysis	10	83,3	11	91,7	6	75,0	7	87,5
12) Time limits for thrombectomy	10	83,3	11	91,7	7	87,5	6	75,0
13) Platelet count that contraindicates thrombolysis	6	50,0	9	75,0	2	25,0	3	37,5
14) Alteplase dosis por thrombolysis	11	91,7	12	100,0	5	62,5	7	87,5
15) Meaning of “mismatch” in TC	10	83,3	11	91,7	6	75,0	4	50,0

Table 4. Performance level by groups over time (n = 20)

	Pre-Test		Post-Test		Paired t-test		Two-way Analysis of Variance			
	mean	DS	mean	DS	t	p-value		F	p-value	η2
Synchronous	11,83	± 2,368	13,92	± 1,240	4,795*	0,001	Time	34,552*	0,000	0,657
Asynchronous	10,13	± 2,100	12,88	± 1,642	3,556*	0,009	Time x Group	0,657	0,428	0,035
Total	11,15	± 2,368	13,50	± 1,469	5,887*	0,000	Group	3,296	0,086	0,155

*The mean difference is significant at the level

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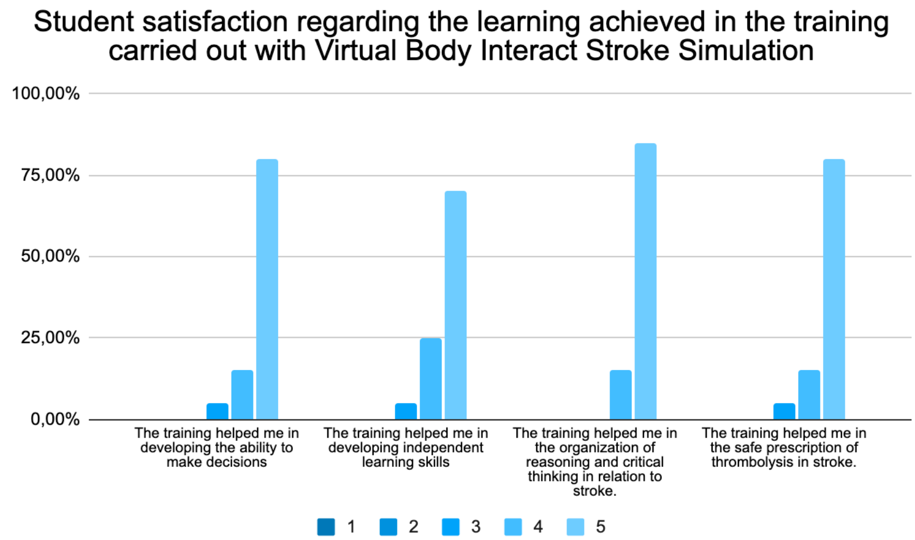

Figure 2. Student satisfaction with the knowledge acquired by working with virtual body (n=20)

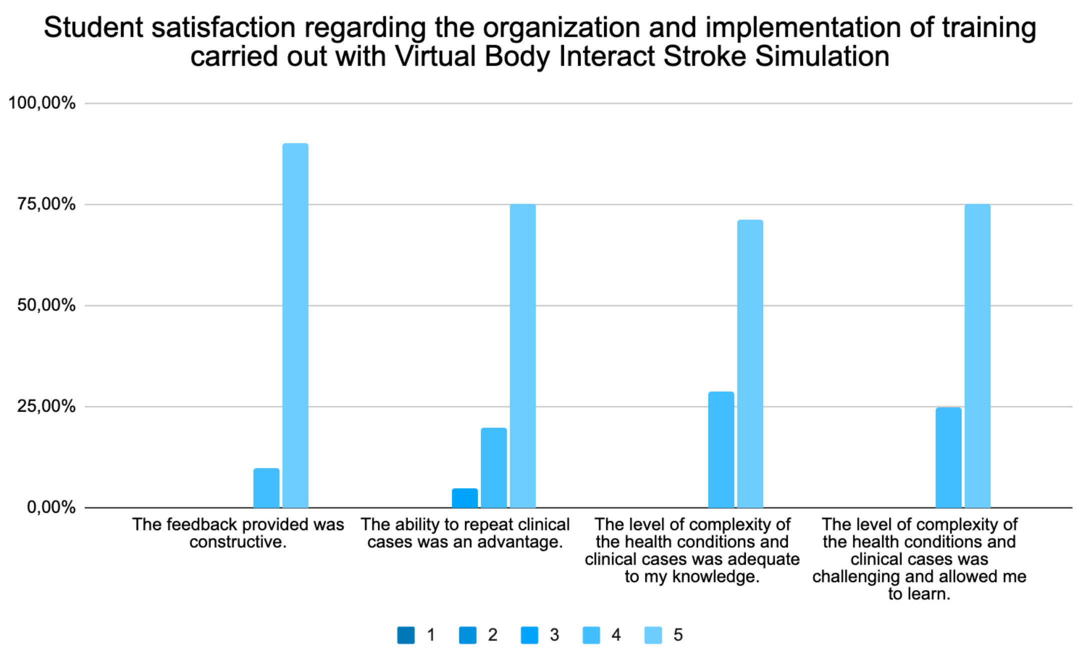

Figure 3. Student satisfaction with the organization and implementation by working with virtual body (n=20)

DISCUSSION

Changes in knowledge pre and post-virtual simulation-based education intervention

In this study, students show significant improvement in medical knowledge related to stroke management after a virtual simulation education-based intervention. Similar results have been found using virtual simulators to manage stroke [4] and other pathologies.[49,50,51,52]

Considering a recent study that demonstrates a low level of achievement in stroke management among medicine graduates,[5] the improvement in post intervention knowledge related to pharmacological aspects of the clinical decision-making process in special cases (anticoagulated and high blood pressure patients) that we found allows us to propose that the use of stroke virtual simulated scenarios is helpful to strength the safe prescription of thrombolysis in medicine students.

Differences in post-test knowledge between groups

Our research showed no significant difference in post-test knowledge between the groups that received synchronous instructor-guided feedback versus automatic and asynchronous feedback, with an estimated effect size also not significant. Consequently, the hypothesis cannot be rejected. These results are similar to those previously described for virtual simulators used as educational resources for nursing, respiratory therapy, and medicine students[53,54,55,56,57] Independent of the intervention (automatic feedback or instructor-guided feedback), the experience of simulation-based education with feedback for stroke management generates positive learning in students. These results support that using virtual simulators as didactic strategies for clinical medical reasoning and pharmacologic prescription is recommended.

Self-perception of achievement

In this study, students report high levels of self-perceived learning, following the general trend of simulation-based education studies, either with virtual simulation [4,8-10] or with other simulation resources.[5,11,12]

Our results show that the autonomous feedback of the software generates a positive change in participants' knowledge, and it is not possible to demonstrate that the magnitude of this change is less significant than that of instructor-guided feedback.

As long as there are no studies that show that there is an objective difference in favor of instructor-guided feedback, the use of a virtual simulator with autonomous feedback offers an opportunity to amplify effective learning experiences, which become relevant in settings where there may be a restriction of clinical specialists to provide feedback, or in the context of training or continuing education to maintain skills or adapt them to an evolutionary and changing clinical context where it is relevant to be able to use autonomous learning strategies for lifelong learning.

Students satisfaction

In this study and in other similar ones, it has been seen that students value and are satisfied with the learning achieved through virtual clinical simulations.[4,8,58,59,60,61] The perception of the students about the activity was high, regarding the facilitation and perception of learning reasoning and critical thinking concerning the organization and implementation of the activity and the opportunity of repeat scenarios. It could be said that it is a good system and that the students value and feel comfortable with it.

It is important to remember that there was academic compensation after the autonomous virtual session in this study. Hence, all participants were able to receive feedback from the neurologist. Participants stated in 90 % of the cases that they have experienced the maximum level of satisfaction concerning the instructor's feedback, which coincides with previous reports on the satisfaction or subjective perception related to the instructor-guided debriefing experience.[62,63,64,65,66]

All of these results contribute as proof that the use of virtual simulation as an effective tool when learning specific elements related to stroke.

Limitations

There was a small number of participants in this study. Out of a universe of 87 fourth-year medical students, only 20 participated. We attribute the low participation to the voluntary nature of the activity, together with the null existence of any tangible benefit from it, except for the practice and potential knowledge acquisition. Another factor that could have influenced is the academic load that fourth-year students present in this faculty, being a year with many academic challenges, leaving little time for additional daily activities.

Something that we also consider a limitation is that the students who decide to participate voluntarily are probably more motivated students, so there could be a limitation in generalizability.

Also, the Sars-Cov-2 pandemic restrictions made comparing our results with face-to-face simulation impossible. This leaves the door open to further studies on the subject.

Interpretation

The use of virtual simulation proves to be an effective tool when learning specific elements related to stroke. It stands out that synchronous simulation with instructor-guided feedback and virtual simulation with automatic feedback allow for improved knowledge without significant differences between both. This shows that virtual simulation is a good tool for the undergraduate curriculum. We should take advantage of it, taking it into account and adding it to the curricular plans of medical schools to contribute to future education.

Regarding the students' perception, the majority proved to be satisfied with the learning achieved during the simulation and with respect to the organization and implementation of the activity. So it could be said that it is a good system, feasible and acceptable, and that the students value it and feel comfortable with it.

CONCLUSIONS

Few randomized studies compare specific aspects of learning about clinical reasoning in medical students. This study provides concrete evidence of two specific areas of improvement: decision-making and safe pharmacological prescribing in stroke.

Based on our results, using a virtual simulator with autonomous feedback offers an opportunity to amplify effective learning experiences without relying on feedback from highly specialized professionals whose time can be devoted to other teaching duties, such as direct clinical supervision in the context of training or continuing education.

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FINANCIACIÓN
Los autores no recibieron financiación para el desarrollo de la presente investigación

CONFLICTO DE INTERESES
Los autores declaran que no existe conflicto de intereses.

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